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13. ABSTRACT

Describes a method for evaluation of materiel physical characteristics. Discusses preliminary activities, facilities, and equipment required. Provides procedures for wheeled, tracked, and special purpose vehicles; armament and individual weapons; ammunition and explosives; missile and rocket systems; electronic, avionic, and communications equipment; aviation, air delivery equipment, and aircraft weapons subsystems; chemical and radiological equipment; construction, support, and service equipment; and general supplies and equipment. Applicable to all categories. Appendices provide procedures for center of gravity, moments of inertia; special measurements, and projectile characteristics.

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U. S. ARMY TEST AND EVALUATION COMMAND
DEVELOPMENTAL TEST II (DT) - COMMON TEST OPERATIONS PROCEDURES

AMSTE-RP-702-100
*Test Operations Procedure 1-2-504 31 October 1972

PHYSICAL CHARACTERISTICS

*This TOP supersedes MTP 4-2-800, 5 October 1966; MTP 6-2-500, 1 April 1967; and MTP 10-2-500, 15 March 1967, including all changes.

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SECTION I
GENERAL

1. Purpose and Scope.

a. This common test operations procedure (TOP) establishes procedures and methodologies for determining the physical characteristics, as defined in AR 310-25, of all categories of equipment and supplies undergoing a developmental test II (ET) as prescribed in AR 70-10 (appendix A). The project engineer will use this common TOP as a guide for preparing the test plan, conducting the test, and analyzing and reporting the physical characteristics test results.

b. The procedures and methodologies will generate adequate and accurate data to enable the ET agency to determine the degree to which the equipment and supplies (test item) meet the physical characteristics criteria specified in the army regulations, requirements documents, technical specifications, federal standards, military standards and industrial standards, and to assist the reviewing agencies in determining whether further development is required or whether the test item is ready for further testing.

c. The common TOP provides for objective and subjective analysis of test data to determine whether the test item meets specified physical characteristics criteria. In the event that the test item does not meet the criteria for particular measurements or configurations, the project engineer will include in his report of test an objective analysis for recommending further development, where required, or a subjective analysis based on technical or military experience and judgment, of the effect this will have on the overall technical performance of the test item.

d. The environmental conditions for conducting the ET using the procedures presented herein are those associated with climatic categories 1 through 8 specified in AR 70-38 (appendix A), that are appropriate to the specific test agency, and as modified by the test directive.

2. Background. The physical characteristics of a test item are determined and recorded during ET. The ET will determine whether the test item meets or exceeds the physical characteristics criteria specified in the requirements documents. The failure of a test item to meet specified physical characteristics criteria may in itself constitute a basis for the determination of further development required.

3. Equipment and Facilities.

a. General. The following is a representative listing of equipment and facilities required in determining the physical characteristics of all categories of equipment and supplies.

b. Equipment.

(1) Test item, its subsystems and components, ancillary equipment, and any other government furnished equipment or documents required to support the test item.

(2) Maintenance test package.

(3) Materials handling equipment.

(4) Linear measuring scales of required size.

(5) Weighing scales of required size.

(6) Micrometers of required size.

(7) Calipers, including vernier, inside and outside.

(8) Dividers of required size.

(9) Steel squares of required size.

(10) Sling cables of required size.

(11) Theodolite or survey transit.

(12) Photographic equipment, still and motion pictures, and film including color and black and white.

c. Facilities.

(1) Maintenance shop facilities.

(2) Level and smooth hardstand.

SECTION II
TEST PROCEDURES

4. Preliminary Activities.

a. The test procedures prescribe the objective, standards, method, data required, and analytical plan. The objective, standards, and analytical plan for all categories of equipment are the same. However, the method and data required vary with each category of equipment. Accordingly, those procedures common to all categories of equipment are presented in paragraph 5. Procedures peculiar to each category of equipment are presented in subsequent subparagraphs by category of equipment.

b. The project engineer will conduct the preliminary activities described in the following common service TOP's prior to conducting physical characteristics tests.

TITLE	PUBLICATIONS NO.
a. Safety	1-2-506*
b. Preoperational Inspections	1-2-505*

5. All Categories of Equipment.

a. Objective. To determine whether the physical characteristics of the test item meet the criteria specified in the requirements documents.

b. Standards. The standards are the applicable criteria obtained from the army regulations, requirements documents, technical specifications, and the federal, military, and industrial standards referenced in applicable equipment categories under paragraph d.

*To be published.

c. Method. The project engineer will prepare a checklist of physical characteristics of the test item to insure that no characteristic is overlooked, based upon the list of physical characteristics contained in the referenced documents, design engineer drawings, and the draft technical manuals provided with the test item. He will obtain the nomenclature from the draft technical manuals and the engineer design drawings. In the event the nomenclature is incomplete, he will use the nomenclature contained in the federal stock catalogue for a standard item, or from professional publications such as the Society of Automotive Engineers (SAE) for a similar item. Test personnel will weigh, measure, and photograph the completely assembled test item and its components, mating parts, and ancillary items, including measurement scales in the photographs, and illustrating features of interest in the test item, in both the operating and traveling configurations. Test personnel will also perform these same operations with the test item disassembled to minimum reducible dimensions and weights for rail, sea, and highway shipment, air transport, airdrop, floating and swimming operations as pertinent to the particular test item. Test personnel will determine the center of gravity locations for which this characteristic is of interest in accordance with appendix B. They will determine the equipment envelope, as illustrated at figures 1 and 2, for conformity with AR 70-44 (appendix A). Test personnel will record the physical characteristics data, including control markings or instruction plates, on the applicable prepared checklists. The material characteristics, as appropriate, will be determined in accordance with paragraph 14, "General Equipment and Supplies". Refer to the following paragraphs covering specific categories of equipment for details on obtaining additional physical characteristics peculiar to those items of equipment.

d. Data required. See the following paragraphs for data required for specific categories of equipment.

e. Analytical plan. The project engineer will present test results in the report in narrative format, supplemented by tables, charts, graphs, and photographs, as required to present results clearly and accurately. He will analyze test results and classify failures as deficiencies or shortcomings where appropriate. He will review equipment performance reports for reclassification and inclusion of data in the test report. He will compare the physical characteristics specified in the referenced documents to determine criteria met and not met. He

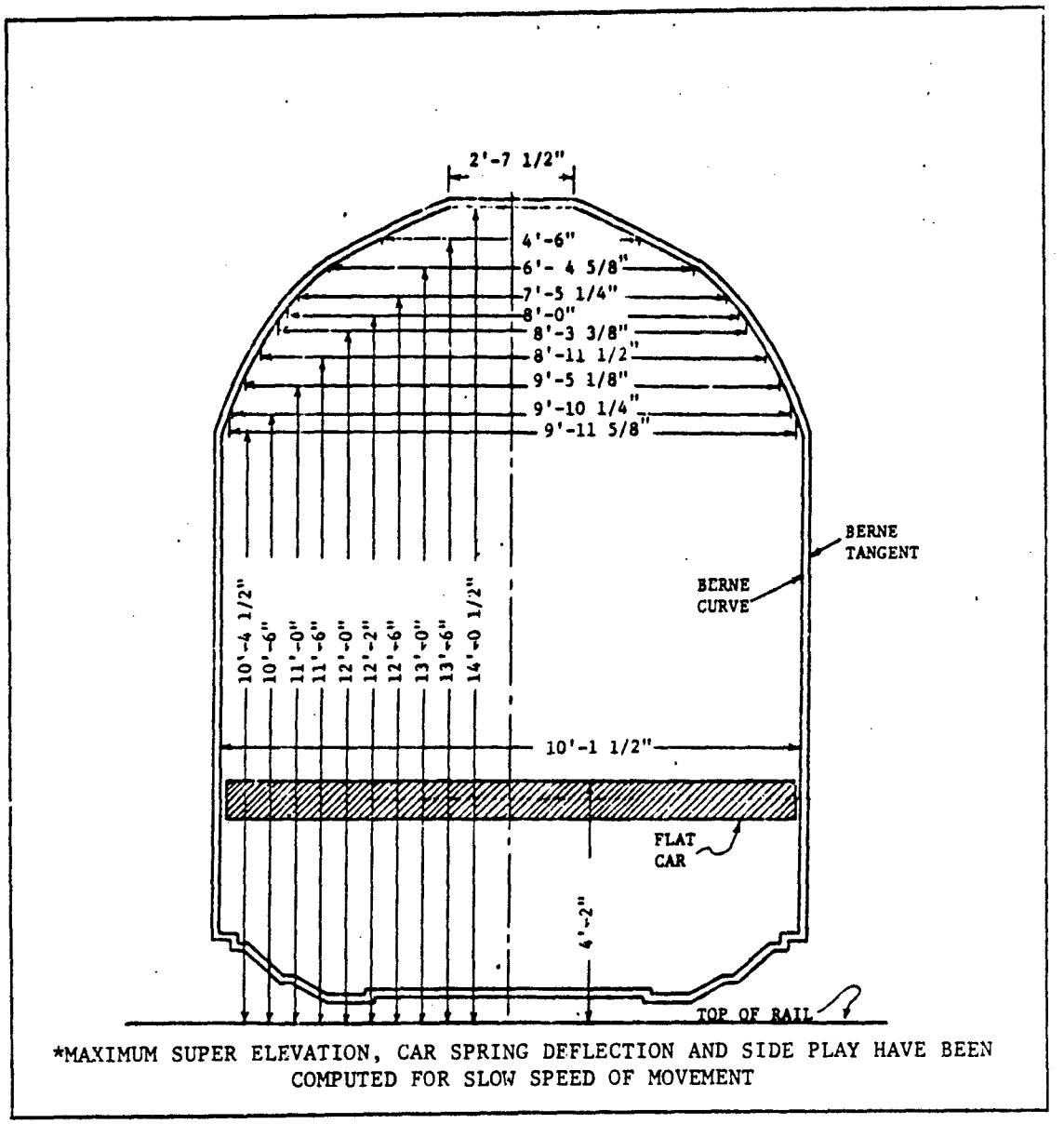

Figure 1. Berne International Reduced Size for 7° Curve Based on 37'-8" (11.48m) Truck Centers

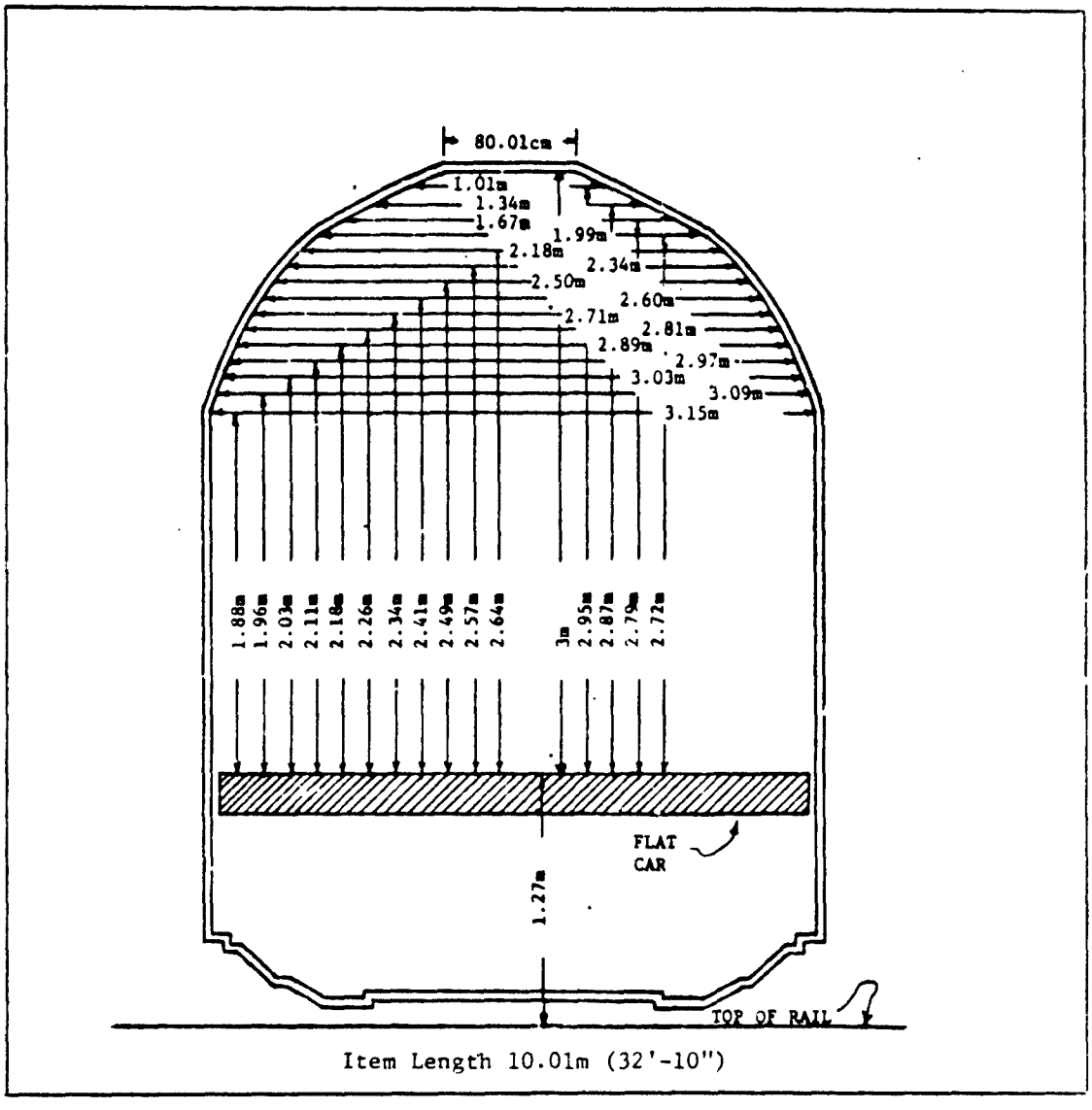

Figure 2. Berne International Clearance Diagram

will specify criteria met or not met, and classify them as deficiencies or shortcomings where appropriate. In the case of deficiencies, he will provide a supporting rationale for classifying the failure as a deficiency. In both cases, he will include an assessment of the impact of the failure on technical performance of the test item. He will also compare the physical characteristics determined by test to those specified in the draft technical manuals to determine errors in the manual. The project engineer will terminate his analysis with a conclusion on whether the test item is acceptable with respect to the objective of the physical characteristics subtest and the specific criteria under consideration.

6. Wheeled, Tracked and Special Purpose Vehicles.

a. Objective. See paragraph 5a.

b. Standards. See paragraph 5b.

c. Method. See paragraph 5c. Test personnel will:

(1) Determine the vehicle envelope, as illustrated at figures 1 and 2, for conformity with AR 70-44 (appendix A).

(2) Determine the vehicle clearance angles, as illustrated at figure 3, in accordance with MTP 2-2-611.

(3) Determine the vehicle center of gravity location in accordance with the appropriate method in appendix B.

(4) Determine the vehicle turning radii in accordance with MTP 2-2-609.

(5) Determine the ground pressure in accordance with MTP 2-2-801.

(6) Determine the physical characteristics of the weapons portion of tanks, self-propelled artillery, and other combat vehicles in accordance with paragraph 7, "Armament and Individual Weapons".

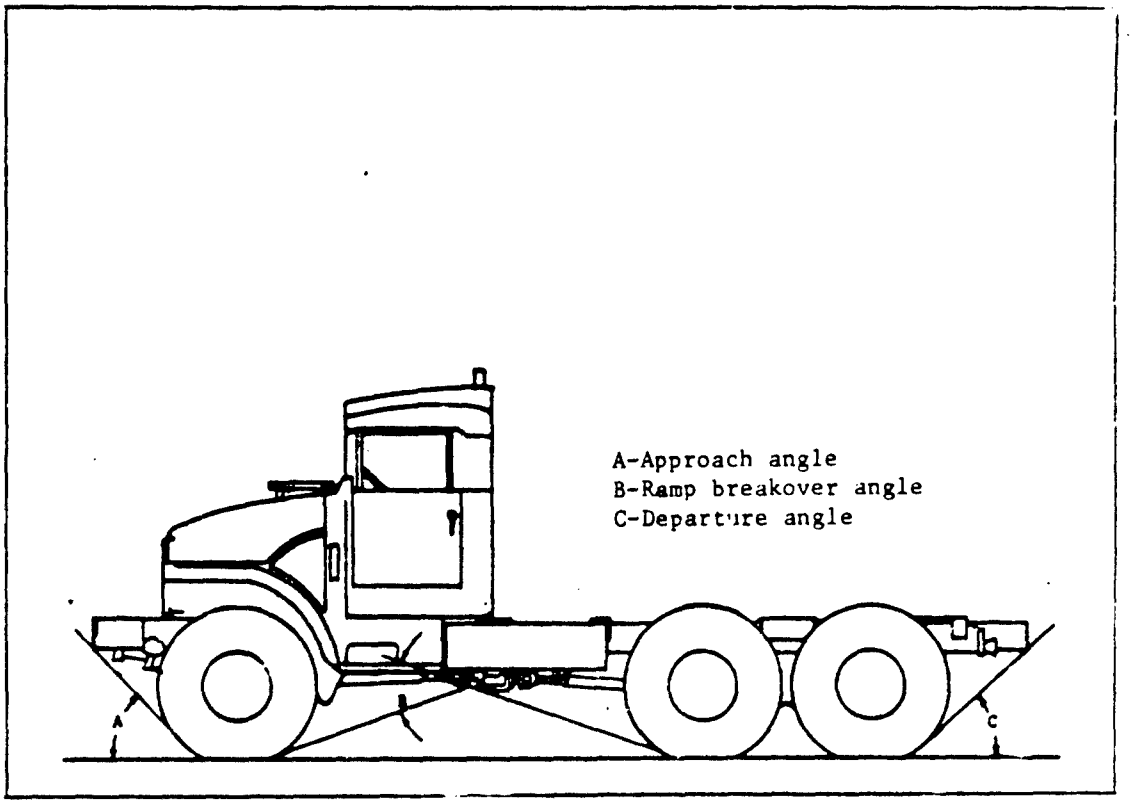

Figure 3. Vehicle Clearance Angles

d. Data required. The project engineer will obtain tne following data:

(1) General.

(a) Nomenclature, serial number, USA registration number, model number, and manufacturer.

(b) The construction of the test item, its subsystems and components, ancillary equipment, kits, chassis, body, armor, packing case material, finish color or shade of paint, and water-proofing. The apparent quality of plating and workmanship including defects, such as cold solder joints, defective welds and sticking or binding of controls.

(c) Photographs of vehicle, complete and reduced, illustrating the front, side, rear, top, and three-quarter front and rear views.

(2) Vehicle (complete and reduced with external components and attachments removed).

(a) Length, width, height, including cargo space and inside body in meters or centimeters as appropriate. Volumes in cubic meters or centimeters, as appropriate. Weight, combat loaded and empty, at front axle, rear axle, and total, in kilograms.

(b) Center of gravity location, when required.

(c) Turning radii in meters or centimeters, as appropriate.

(d) Angles of approach and departure, and ramp angle in degrees.

(e) Number of personnel that can be transported.

(f) Ground pressure in kilograms per square centimeter, and ground clearance in centimeters.

(g) Fifth wheel height, with and without load, and pintle height, with and without load, in centimeters. Towed load capacity and winch rated pull in kilograms. Winch cable diameter and length in centimeters or meters, as appropriate.

(h) Wheel base, tread (front and rear), and tire size in centimeters. Fuel capacity (usable and total) in liters.

(3) Components and attachments including kits (removed from vehicle reduced).

(a) Length, width, and height in meters or centimeters, as appropriate. Volume in cubic meters or centimeters, as appropriate. Weight in kilograms.

(b) Number of personnel and manhours required to remove components, attachments and kits, and the equipment and organizational tools required.

(4) Engine.

(a) Design, accessory drive ratios, type air cleaner, cooling system including coolant, fan size, and number of blades. Air flow in cubic meters per minute. Type radiator and capacity in liters.

(b) Crankshaft rotation including output, number of cylinders, cylinder arrangement and displacement including bore, and stroke in centimeters. Compression ratio, firing order and horsepower rating.

(5) Electrical system.

(a) Type and capacity including voltage and amperes of generator or alternator. Type of ignition such as spark or diesel, battery or magneto. Number and type of spark plugs, and size in millimeters.

(b) Voltage capacity. Type lighting systems including blackout and infrared, and accessory systems, if applicable.

(6) Fuel system.

(a) Fuel specifications including octane rating. Type of filter and metering including type carburetor or injection. Type fuel pump, and supercharger.

(b) Type governor and oil specification (SAE). Fuel and oil capacity in liters.

(7) Power train (each component).

(a) Type including accessories such as power take off ratio and instrument sending units.

(b) Length, width and height in centimeters or meters as appropriate. Weight (dry) in kilograms. Oil types and capacities in kilograms and liters, as appropriate.

(c) Type of braking system, converter including torque, drives including input and output, and clutches.

(d) Gear range clutches, gear ratios and lockup. Type oil cooler, and oil pump rated capacity in liters per minute.

(8) Auxiliary engines.

(a) Type of engine, air cleaner, cooling, and horsepower rating.

(b) Generator or alternator capacity in voltage and amperes, and type of ignition system.

(9) Suspension.

(a) Number and type of suspension system, idlers, shock absorbers, springs, bumper spring stops and track support rollers. Unsprung weight in kilograms.

(b) Wheels, including number, and size in centimeters. Inflated tire pressure in grams or kilograms per square centimeter as appropriate, and total weight in kilograms.

(10) Tracks.

(a) Track area including ground contact with normal load and projected area in square centimeters or meters, as appropriate.

(b) Type of fastening including lock nuts, wedges, and caps.

(c) Type of grousers including hardness, and height in centimeters.

(d) Type of sprocket including hardness of teeth face, pitch angle in degrees, pitch diameter in centimeters, number of teeth, and grouser height in centimeters.

(e) Sprocket material including the bushings, and at road wheel surface and road surface.

(f) Track block hardness at center guide, sprocket contact points, and road surface.

(11) Capacities. Capacities in liters of air cleaners, engine and auxiliary engine crankcase and cooling system, differential, fuel tanks including gross and usable, final drives, gun recoil system, transfer case, and transmission.

(12) Frame and hull. Type and fabrication method.

(13) Personnel heaters. Type, location and capacity in British Thermal Units per hour.

(14) Vehicle winterization. Winterization limits in centigrade (C) with and without kits.

(15) Communication equipment. Type including internal and external.

(16) Armament (Primary).

(a) Type, bore evacuation and bore length in centimeters or meters, as appropriate.

(b) Type of breechblock, equilibration, and muzzle attachments.

(c) Weight in kilograms of gun assembly and tube.

(17) Mount. Type of recoil and replenisher, and recoil distance in centimeters.

(18) Armament (Secondary). Type including mount, location, and any special equipment.

(19) Ammunition. Type and number of rounds in stowage space and location.

(20) Ammunition handling equipment. Type such as dispensing devices, loaders and hoists.

(21) Ventilation equipment. Type and fan capacity in cubic meters per minute.

(22) Sighting equipment and viewing devices. Type of reticle, diopeter adjustment, lense power magnification, range limits and location.

(23) Gun control system. Type, and power source requirements.

e. Analytical plan. See paragraph 5e.

7. Armament and Individual Weapons.

a. Objective. See paragraph 5a.

b. Standards. See paragraph 5b.

c. Method. See paragraph 5c. Test personnel will:

(1) Perform the various inspections and determine the various measurements of cannon in accordance with MTP 3-2-800.

(2) Determine the physical characteristics of army aircraft armament in accordance with MTP 7-1-004.

(3) Record the data on a prepared checklist as illustrated at figure 4. The checklist will contain a photograph of the test item and a list of its principal dimensions and characteristics.

d. Data required. The project engineer will obtain the following data:

(1) General.

(a) Nomenclature, serial number, model number, and manufacturer.

(b) The construction of the test item, its components and ancillary equipment, packing case material, finish, color or shade of paint, and waterproofing. The apparent quality of plating and workmanship including defects, such as cold solder joints, defective welds and sticking or binding controls.

(c) Photographs of the test item and components illustrating front, side, rear, top, and three-quarter front and rear view.

(2) Weapon.

(a) Caliber in millimeters, weight in kilograms, length overall in centimeters or meters, as appropriate, and center of gravity location.

(b) Length of bore in calibers, number of lands and grooves, rifling twist, projectile travel distance in tube in millimeters, and volume of chamber in cubic centimeters.

(c) Type of muzzle attachments, loading mechanism, breech mechanism, and firing mechanism.

(3) Recoil mechanism.

(a) Type mechanism, normal and maximum recoil length, and maximum piston rod pull in centimeters.

(b) Weight in kilograms of recoil mechanism and recoiling parts.

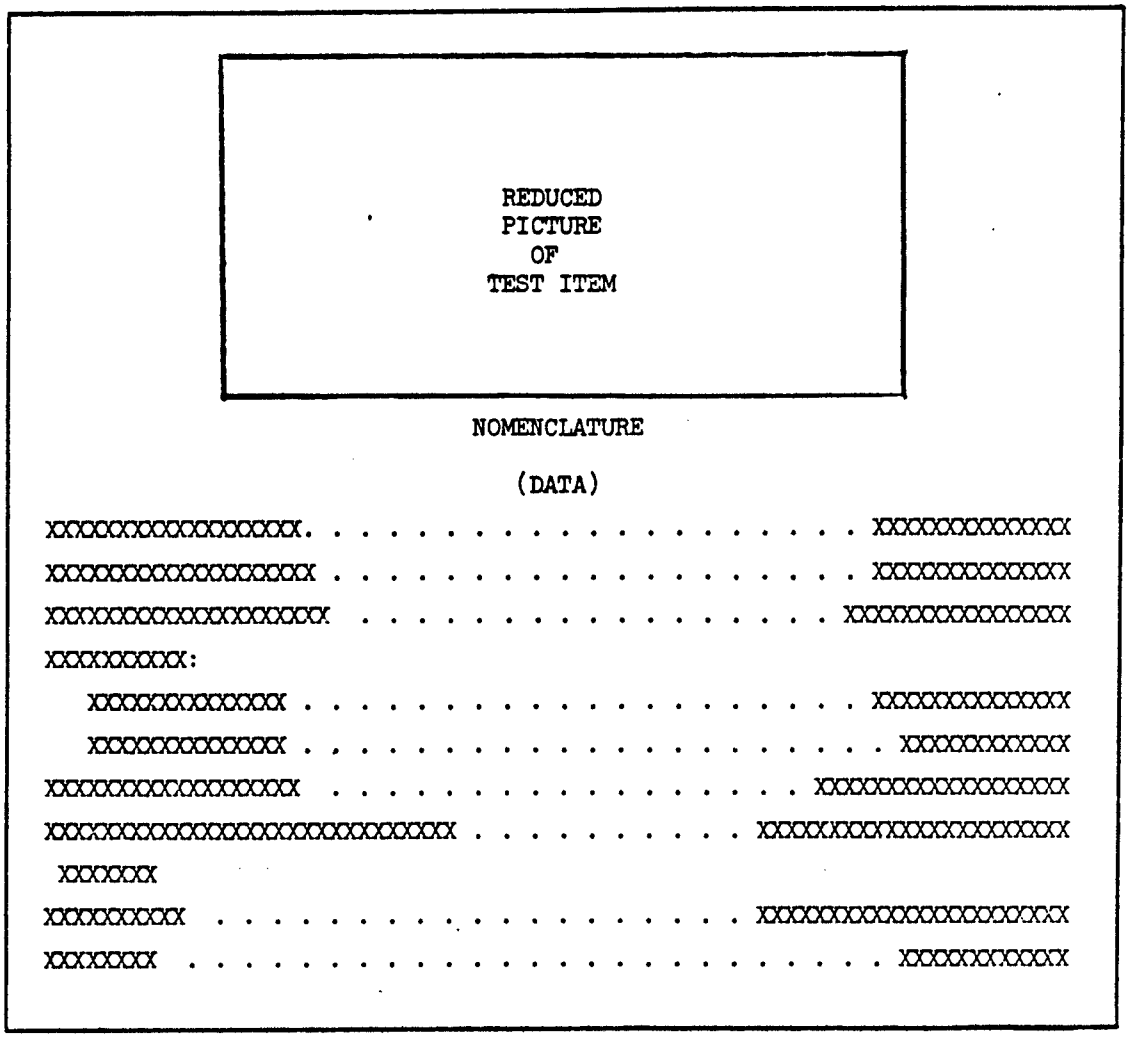

Figure 4. Physical Characteristics

(4) Carriage.

(a) Weight in kilograms with and without weapon. Length with weapon, and height with weapon emplaced and in travel position, and width of carriage in meters or centimeters, as appropriate.

(b) Height of lunette limbered, height of trunnions when emplaced, distance from centerline of trunnions to muzzle, road clearance, trail spread, and tread width in meters or centimeters, as appropriate.

(c) Maximum elevation and depression, and maximum traverse left and right in mils.

(d) Loading angles in mils. Type of firing support, brakes, wheels, equilibrator and number, and fire control equipment. Type of tires and size in centimeters.

(5) Recoilless rifles.

(a) Length, width, height, diameter of tube or barrel, in centimeters.

(b) Weight and vent pressure in kilograms. Center of gravity location.

(c) Caliber in millimeters. Type of breech mechanism, and firing mechanism.

(d) Length of bore in millimeters. Number of lands and grooves, rifling twist. Projectile travel distance in tube in millimeters. Volume of chamber in cubic centimeters.

(6) Mortars.

(a) Length overall and length of tube in centimeters. Weight in kilograms of mortar with basecap, complete mount, and baseplate.

(b) Method of loading and firing, temperature limitations, and type ammunition used with mortar.

(7) Rocket or missile launcher.

(a) Length overall, length and number of tubes or rails, width overall, height overall in travel and firing position (emplaced) in centimeters or meters, as appropriate. Weight overall in kilograms.

(b) Height of trunnions above ground when emplaced, and type and size of wheels and tires in centimeters.

(c) Type of firing mechanism, fire control, mounting, brakes, and ammunition used.

(d) Maximum elevation and depression, and maximum traverse right and left in mils.

(8) Small arms - pistols.

(a) Caliber in millimeters and length overall in centimeters. Weight in kilograms with and without magazine empty and loaded, and number of rounds.

(b) Sight radius and barrel length and rifling in millimeters. Number of grooves and pitch and direction.

(c) Type of operation and breech lock such as toggle and tilting barrel. Firing position. Type of fire such as semi or full automatic, and automatic fire cyclic rate.

(9) Small arms - revolvers.

(a) Caliber in millimeters and length overall in centimeters. Weight in kilograms unloaded and loaded, and number of rounds.

(b) Sight radius and barrel length and rifling in millimeters. Number of grooves and pitch and direction.

(c) Type of operation such as single or double action, direction of cylinder rotation, and type of cylinder opening.

(10) Small arms - magazine - fed shoulder weapons.

(a) Caliber in millimeters. Overall length in centimeters with and without bayonet. Length in centimeters with stock folded or retracted.

(b) Weight in kilograms, with and without magazine, bayonet, sling, grenade launcher, bipod and cleaning kit. Weight empty and loaded and number of rounds.

(c) Type sight and radius. Barrel length with and without muzzle brake and suppressor. Rifling length in millimeters. Number of grooves and pitch and direction.

(d) Type of operation including type breech lock, and firing position. Type of fire such as semi or full automatic and automatic cyclic rate.

(11) Small arms - belt and magazine - fed automatic weapons.

(a) Caliber in millimeters, length overall, with and without muzzle brake, suppressor, and compensator in centimeters, as appropriate.

(b) Weight in kilograms with and without magazine or feeder, empty and loaded, and number of rounds.

(c) Type sight and radius, and range graduations. Barrel length with and without muzzle brake, suppressor, and compensator in centimeters, as appropriate.

(d) Rifling length in millimeters. Number of grooves and pitch and direction.

(e) Type of operation such as breech lock. Type of firing such as automatic cyclic rate and assembly such as quick change and fixed headspace. Type of firing position and ammunition belt.

e. Analytical plan. See paragraph 5e.

8. Ammunition and Explosives.

a. Objective. See paragraph 5a.

b. Standards. See paragraph 5b.

c. Method. See paragraph 5c. Test personnel will:

(1) Determine the center of gravity location of projectiles in accordance with paragraph 6, appendix B.

(2) Determine the moments of inertia of projectiles in accordance with appendix C.

(3) Determine the quality of projectile surface finish, and bullet pull force in accordance with applicable paragraphs in appendix D.

(4) Determine applicable physical characteristics of small arms ammunition in accordance with TOP 4-2-604.

(5) Determine the projectile unbalance, when required, in accordance with TOP 4-2-801.

(6) Determine the projectile seating measurement in accordance with MTP 4-2-802.

(7) Determine the projectile rotating band seating measurements, when required, in accordance with MTP 4-2-803.

(8) Measure the test item and components using appendix E as a guide for projectiles, and determine the applicable data listed under paragraph d.

d. Data required. The project engineer will obtain the following data:

(1) General.

(a) Nomenclature, model number, federal stock number, manufacturer, lot number and date of manufacture, and legibility of markings.

(b) The construction of the test item and its components, packing containers, waterproofing, finish and color or shade of paint, and apparent quality of workmanship.

(2) Cartridges and complete rounds.

(a) Weight in kilograms to the nearest 0.05 kilogram, as appropriate, of cartridges or complete rounds, and of projectile in flight.

(b) Type projectile filler and weight in grams, and the weapon in which the cartridge or rounds is designed to be used.

(3) Rocket motors or complete rounds that contain rocket motors.

(a) Length in centimeters or meters, as appropriate. Diameter in millimeters to the nearest 0.01 millimeter. Total weight in kilograms to the nearest 0.05 kilogram.

(b) Weight of propellant grain or grains in grams or kilograms, as appropriate.

(c) Description of propellant including: nomenclature or chemical composition; single or number of multiple grains; shape of grain such as tubular or cruciform; and mounting method such as propellant trap or head-end suspended.

(d) Description of rocket motor body including material. Diameter in millimeters. Wall thickness in centimeters. Weight (empty) in grams or kilograms.

(e) Description of stabilization method such as spin-stabilized, fin-stabilized including fixed, folding, pop-out, or wraparound, and fin-stabilized with limited spin.

(f) Description of rocket motor nozzles including number, location, and arrangement of nozzles.

(g) Description of nozzle such as converging or converging-diverging with subsonic, sonic, or supersonic flow. Include nozzle throat and nozzle exit diameter in millimeters. Nozzle length in centimeters. Nozzle expansion ratio or expansion cone half angle in mils or degrees, and materials used in nozzle assembly and throat area.

(h) Description of rocket motor igniter including electrical or percussion actuation, location in rocket motor, and composition and quantity of explosives contained in igniter.

(i) Static firing data including weight in grams or kilograms to the nearest 0.05 kilograms of the rocket or motor before and after firing. Conditioned temperature in centigrade. Internal pressure at average and peak conditions in kilograms per square centimeter. Average and peak thrust in kilograms per square centimeters or meters, as appropriate. Effective burning time in minutes and seconds, total impulse (thrust-time integral), and specific or propellant impulse (total impulse divided by weight of propellant).

(4) Projectiles.

(a) Weight, as fired, in grams or kilograms to the nearest 0.05 kilogram, as appropriate.

(b) Length overall including fuzed projectiles in centimeters. Bourrelet diameter above and below the rotating band in millimeters to the nearest 0.01 millimeter.

(c) Type of rotating band and material, rotating band diameter in millimeters to the nearest 0.01 millimeter. Base type such as boat tail, square or hemispherical.

(d) Baseplate size and thickness and band seat width in centimeters. Type of knurling.

(e) Type of crimp and radius to projectile crimping groove and ogive in millimeters to the nearest 0.01 millimeter.

(f) Composition of steel in projectile body. Center of gravity location. Axial and transverse moments of inertia.

(g) Type case used with projectile.

(h) Tracer visibility and minimum and maximum burning time in seconds. Effectiveness of illumination.

(5) Cartridge cases.

(a) Weight in grams or kilograms to the nearest 0.05 kilogram, as appropriate. Length including minimum and maximum allowance in centimeters. Volume of cartridge case empty in cubic centimeters. Diameter in millimeters to the nearest 0.01 millimeter.

(b) Type material such as metal, consumable and combustible. Type primer used, and type liner.

(c) Width of flange in centimeters, perforations including number and size in centimeters. Bullet pull force in kilograms.

(6) Propellant charge:.

(a) Type bag charges including composition, grade and bag material.

(b) Web size and type such as single perforated, multiperforated, disk, and flake, and charge weight in grams.

(c) Grain minimum and maximum length in centimeters. Grain minimum and maximum diameter in millimeters to the nearest 0.01 millimeter.

(d) Charge diameter in millimeters to the nearest 0.01 millimeter. Weight of charge in grams or kilograms, as appropriate.

(e) Type igniters, flash suppressors, or other components and type primer used. Method of assembly in cartridge case, and density of loading.

(f) Diameter of grain and diameter of perforation ratio, (D/D ratio) in millimeters.

(7) Fuze.

(a) Weight loaded in grams. Type thread and size, length in centimeters, and diameter in millimeters to the nearest 0.01 millimeter.

(b) Safety features such as minimum arming setback including g's and angular acceleration.

(c) When used with a lock assembly, the full circuit will be shown photographically, and the resistance values indicated.

(8) Booster.

(a) Weight in grams. Length in centimeters, and diameter in millimeters to the nearest 0.01 millimeter.

(b) Type thread and size in millimeters.

(9) Primer.

(a) Number of grains and weight in grams. Length in centimeters, and diameter in millimeters to the nearest 0.01 millimeter.

(b) Type thread and size in millimeters. Method of fit such as threaded or pressed. Weight of load in grams. Type of loading, resistance for electric primers. Type propellant used.

(10) Prefiring measurements of projectiles.

(a) All projectiles. Length in centimeters and diameter in millimeters (measured at 90° intervals in two planes) of bourrelet, body, and rotating band.

(b) Experimental projectiles and projectiles used in range firing. Rotating band width, distance from rotating band rear edge to projectile base, distance from rotating band rear edge to the line of the boat tail taper in centimeters. Angle in mils or degrees of the boat tail taper.

(c) Experimental projectiles. Fuze length in centimeters. Radius of ogive in millimeters. Nose angle in mils or degrees.

(11) Postfiring and recovery measurements of projectiles.

(a) Length in centimeters. Diameters in millimeters of bourrelet, and body.

(b) Photographs or sketches indicating evidence of engraving, deformation and damage.

(12) When diameter measurements are taken on tapered portions of projectiles such as boattails and ogives in steps (10 and (11), special fixtures must be fabricated to insure that prefiring and postfiring measurements are taken at the identical positions.

e. Analytical plan. See paragraph 5e.

9. Missile and Rocket Systems.

a. Objective. See paragraph 5a.

b. Standards. See paragraph 5b.

c. Method. See paragraph 5c. Test personnel will:

(1) Determine the rocket or missile chemical and metallurgical characteristics in accordance with MTP 5-2-585.

(2) Determine the special purpose vehicles physical characteristics measurements in accordance with paragraph 6, "Wheeled, Tracked and Special Purpose Vehicles."

(3) Determine the rocket or missile launcher physical characteristics measurements in accordance with paragraph 7, "Armament and Individual Weapons."

(4) Determine the rocket or missile physical characteristics measurements in accordance with the applicable portion of paragraph 8, "Ammunition and Explosives."

(5) Determine the missile guidance electronics, electronic ancillary equipment, and communications equipment physical characteristics measurements in accordance with paragraph 10, "Electr[illegible]c, Avionic, and Communications Equipment."

d. Data required. The project engineer will obtain the following data:

(1) General.

(a) Nomenclature, serial number, model number, federal stock number, USA registration number, manufacturer, lot number and date of manufacture, and legibility of markings.

(b) The construction of the test item, its subsystems and components, and ancillary equipment, packing case material, rocket or missile storage containers, waterproofing, finish and color or shade of paint. The apparent quality of workmanship and plating, including defects such as cold solder joints, defective welds and sticking or binding controls.

(c) Photographs of the test item, its subsystems and components, and ancillary equipment illustrating front, side, rear, top and three-quarter front and rear view.

(2) Special purpose vehicles. The applicable data listed under paragraph 6.

(3) Rocket or missile launcher. The applicable data listed under paragraph 7d(7).

(4) Rocket or missile. The applicable data listed under paragraph 8d(3).

(5) Missile guidance electronics, communications and electronic ancillary equipment. The applicable data listed under paragraph 10d.

e. Analytical plan. See paragraph 5e.

10. Electronic, Avionic and Communications Equipment.

a. Objective. See paragraph 5a.

b. Standards. See paragraph 5b.

c. Method. See paragraph 5c. Test personnel will:

(1) Record the test item nomenclature, serial number, and manufacturers name.

(2) Record the test equipment nomenclature, serial number, accuracy tolerances, calibration requirements, and date of last calibration of the test equipment selected for the tests.

(3) Arrange the test item for transportation, installation, or other configuration as indicated by intended usage, technical design, and test requirement.

(4) Prepare a brief description of the nature of the equipment, its intended military application, and general physical configuration.

d. Data required. The project engineer will obtain the following data:

(1) Preparation for test.

(a) Nomenclature, serial number, and manufacturer of test item.

(b) Nomenclature, serial number, accuracy tolerance, calibration requirements, and date last calibrated of test equipment selected for the test.

(c) Identification of aircraft, vehicle, or shelter in which the test item is mounted or transported.

(2) General.

(a) Description of the nature of the equipment, intended military application, and general physical configuration. The description will include, but will not be limited to, the number and type of major components and ancillary equipment in the packed and unpacked conditions, modular construction features, and the arrangement of components when installed for operation, when applicable.

(b) Description of the test item and components geometry when packed for displacement and when installed for operation. Include reference to unusual forms, protuberances (fixed or removable) and shapes designed for special applications. The silhouette of items which may be subjected to enemy observation in combat areas.

(c) Description of test item construction including chassis, cabinet, and packing case material, finish, color or shade of paint, and waterproofing. The apparent quality of plating and workmanship including defects such as cold solder joints, defective welds and sticking or binding controls.

(d) Appropriate photographs and sketches with captions to support the descriptions in steps (a) through (c) above.

(3) Physical dimensions.

(a) The length, width, height, depth, radii, diameter, wall thickness, and other applicable dimensions in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate. Weight in kilograms of the complete test item, major components and major ancillary equipment such as power units, test sets and large interconnecting cables in both the packed and unpacked configuration.

(b) The length, width, height and diameter in centimeters or meters, as appropriate. Volume in cubic centimeters, as appropriate. Weight in kilograms of minor ancillary item such as test cords, tools, and spare parts in packed configuration.

(4) Test item permanently mounted in electrical equipment shelter, van, or trailer.

(a) Method of mounting and securing test item components and ancillary equipment.

(b) Location and size of entrances and exits (ingress, egress) in centimeters.

(c) Arrangement of test item components and ancillary equipment including space occupied by each component, space between components, aisle dimensions, and crew space available during operations in centimeters or meters, as appropriate.

(5) Test item installed in aircraft or combat vehicles (no special shelter).

(a) Method of mounting and securing components and ancillary equipment.

(b) The same information required in 4(b) and (c).

(6) Center of gravity locations of the test item and non-attached parts.

(7) Material characteristics data as determined under paragraph 14, "General Equipment and Supplies."

(8) Test personnel comments and observations.

e. Analytical plan. See paragraph 5e.

11. Aviation, Air Delivery Equipment and Aircraft Weapons Subsystems.

a. Objective. See paragraph 5a.

b. Standards. See paragraph 5b.

c. Method. See paragraph 5c. Test personnel will:

(1) Determine the physical characteristics of ground support special purpose vehicles in accordance with paragraph 6, "Wheeled, Tracked and Special Purpose Vehicles."

(2) Determine the physical characteristics of army aircraft armament in accordance with MTP 7-1-004 and paragraph 7, "Armament and Individual Weapons."

(3) Determine the physical characteristics of army aircraft ammunition in accordance with paragraph 8, "Ammunition and Explosives."

(4) Determine the physical characteristics of ground support electronic and avionic equipment in accordance with paragraph 10, "Electronic, Avionic and Communications Equipment."

(5) Determine the physical and material characteristics of protective clothing, survival and rescue equipment and general equipment in accordance with paragraph 14, "General Supplies and Equipment."

d. Data required. The project engineer will obtain the following data:

(1) General.

(a) Nomenclature, serial number, model number, federal stock number, USA registration number, manufacturer, lot number and date of manufacture, and legibility of markings.

(b) The construction of the test item, its components and ancillary equipment, packing case or shipping container material, waterproofing, finish, and color or shade of paint. The apparent quality of plating and workmanship including defects such as cold solder joints, defective welds, and sticking or binding controls.

(c) Photographs of the test item, its components and ancillary equipment illustrating front, side, rear, top, and three-quarter front and rear view.

(2) Ground support special purpose vehicles. The applicable data listed under paragraph 6d.

(3) Army aircraft armament. The applicable data listed under paragraph 7d.

(4) Army aircraft ammunition. The applicable data listed under paragraph 8d.

(5) Ground support electronic and avionic equipment. The applicable data listed under paragraph 10d.

(6) Protective clothing, survival and rescue equipment, and general equipment. The applicable data listed under paragraph 14d.

e. Analytical plan. See paragraph 5e.

12. Chemical and Radiological Equipment.

a. Objective. See paragraph 5a.

b. Standards. See paragraph 5b.

c. Method. See paragraph 5c. Test personnel will:

(1) Select test item samples at random and prepare sketches and narrative descriptions of the items.

(2) Determine the radial and longitudinal center of gravity locations of chemical projectiles in accordance with paragraph 6, Appendix B.

(3) Determine the physical characteristics of chemical ammunition in accordance with paragraph 8, "Ammunition and Explosives."

(4) Take appropriate photographs of the test item, its components and ancillary equipment:

(a) In the operating or ready-for-use configuration.

(b) When packed in transit cases or prepared for tactical transport.

d. Data required. The project engineer will obtain the following data:

(1) General.

(a) Nomenclature, identification number, serial number, manufacturer, contract number and date, manufacturer lot number and date of manufacture, and legibility of markings to conform with MIL-STD-129(1), MIL-STD-709(-), and MIL-M-19590 (appendix A).

(b) The construction of the test item, its components and ancillary equipment, packing container or transit case material, waterproofing, finish, and color or shade of paint. The apparent quality of plating and workmanship including defects such as cold solder joints, defective selds, and sticking or binding controls.

(c) Photographs of the test item, its components and ancillary equipment illustrating front, side, rear, top, and three-quarter front and rear view.

(d) Sketches and narrative description of the test item.

(2) Chemical ammunition. The applicable physical characteristics data listed under paragraph 8d, including center of gravity locations for projectiles.

(3) Chemical equipment. In both the operating or ready-for-use configuration and packed in transit cases or prepared for tactical transport.

(a) Weight in grams or kilograms, as appropriate.

(b) Length, width, height, diameter in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate.

e. Analytical plan. See paragraph 5e.

13. Construction, Support and Service Equipment.

a. Objective. See paragraph 5a.

b. Standards. See paragraph 5b. The federal, military, and industrial standards listed in supporting test paragraph 14d, "General Supplies and Equipment."

c. Method. See paragraph 5c. Test personnel will:

(1) Determine the physical characteristics of the vehicle and automotive portion of the test item in accordance with paragraph 6, "Wheeled, Tracked and Special Purpose Vehicles."

(2) Determine the physical characteristics of the electronic portion of the test item in accordance with paragraph 10, "Electronic, Avionic and Communications Equipment."

(3) Determine the material characteristic data of the test item in accordance with paragraph 14, "General Supplies and Equipment."

d. Data required. The project engineer will obtain the following data:

(1) General.

(a) Nomenclature, USA registration number, model number, serial number, code markings, manufacturer and date of manufacture, instruction plate and military specification, type or class.

(b) The construction of the test item, its components and ancillary equipment, packing containers, crates, or transit cases, material, waterproofing, finish, and color or shade of paint. The apparent quality of plating and workmanship including defects such as cold solder joints, defective welds, and sticking or binding controls.

(c) Photographs, sketches and narrative description of the test item, its components and ancillary equipment, illustrating front, side, rear, top, and three-quarter front and rear view.

(2) Bath units, (operational and transport configurations).

(a) Length, width, height, diameter in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate.

(b) Total weight, crated and uncrated, in kilograms. The crated center of gravity location of the test item and nonattached components.

(c) Water tank, fuel tank, and crankcase capacities in liters. Battery capacity in volts and amperes.

(d) Bath capacity by number of personnel and the applicable material characteristics data listed under paragraph 14d.

(3) Buildings, prefabricated. (Crated and uncrated configuration.)

(a) Length, width, height, in meters. Volume in cubic meters.

(b) Weight in kilograms and crated center of gravity locations.

(c) Building capacity in square meters and the applicable material characteristics listed under paragraph 14d.

(4) Bridges, fixed, military.

(a) Length, width, height, in meters. Volume in cubic meters.

(b) Weight in kilograms, and crated center of gravity locations.

(c) Bridge capacity in metric tons or kilograms, as appropriate, and the applicable material characteristics listed under paragraph 14d.

(5) Crane truck, warehouse.

(a) The applicable vehicle physical characteristics data listed under paragraph 6d and the center of gravity locations.

(b) The crane method of operation including hydraulic or mechanical and type of crane such as, petroleum fueled, electrically powered, and towed.

(c) Type of boom such as telescopic, fixed or extension, and maximum rated load in kilograms.

(d) Type of outriggers such as hydraulic adjustable or manually adjustable. Type of lifting line including length and diameter in centimeters or meters, as appropriate. Boom topping system such as hydraulic or cable.

(e) The applicable material characteristics data listed under paragraph 14d.

(6) Crane, shovel, tracked and wheeled.

(a) The applicable vehicle and automotive physical characteristics listed under paragraph 6d and the center of gravity locations.

(b) The data listed under subparagraph (5)(b) through (e).

(7) Trailer, cable reel.

(a) Safety equipment provided. Weight in kilograms. Length, width, and height in centimeters or meters, as appropriate.

(b) Number and size of wheels, and number and size of tires including spare, in centimeters. Number and location of tie-downs.

(8) Crushing, screening, and washing plant.

(a) The applicable vehicle and automotive physical characteristics data listed under paragraph 6d and the center of gravity locations.

(b) The applicable physical and material characteristics listed under paragraph 14d.

(9) Road graders.

(a) The applicable vehicle and automotive physical characteristics data listed under paragraph 6d and center of gravity locations.

(b) Counterweight information. Drive-steer provisions such as four-wheel drive, front-wheel drive. Starting engine data and safety equipment supplied.

(10) Liquid transporting and dispensing equipment.

(a) The applicable vehicle and automotive physical characteristics data listed under paragraph 6d, the applicable material characteristics listed under paragraph 14d. Center of gravity locations.

(b) Type and class of storage tanks, pump and power unit, filter or separator, manifold, hose reels, metering unit, hose and fittings, nozzles, valves, tiedown equipment, grounding rods and fuel tanks, and safety equipment.

(c) Weight in kilograms. Length, width, height in meters. Volume in cubic meters. Storage tank capacity in liters. Number and location of tiedowns.

(11) Electrostatic printing equipment.

(a) The applicable electronic and electrical equipment shelter physical characteristics data listed under paragraph 10d.

(b) Number and location of lifting points and the center of gravity locations.

(12) Motors, electrical.

(a) The applicable electronic physical characteristics data listed under paragraph 10d.

(b) Electrical type such as AC, DC. Universal, internal construction or type winding. Horsepower rating, duty cycle, maximum ambient service temperature in centigrade. Rated voltage and frequency, full load torque, lock rotor torque and current, full load current, full load speed and efficiency. Type enclosure, direction of rotation. Type of electrical connectors, lubrication required, overload protection, operating position, and class of insulation. Total weight in kilograms.

(13) Air compressor.

(a) Length less drawbar, width, height, in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate. Ground clearance in centimeters. Gross weight in kilograms.

(b) Wheelbase in centimeters or meters, as appropriate. Drawbar pull in kilograms. Center of gravity locations.

(14) Tools, hand, pneumatic.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in kilograms. Length, width, height, diameter in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate. Center of gravity location, when required.

(c) The Rockwell C hardness requirements of: chain drive spocket teeth; hard surfacing rod, the bar rails, guide bar, cutter teeth, tie bars, drive rods; and the accessory steels such as axe blade, chisel, moil print, pick, spade tamping rod, tamping bar, and cribbing fork.

(d) Sprocket pitch in degrees or mils, as appropriate. Sprocket diameter in centimeters or millimeters, as appropriate.

(15) Pump, centrifugal.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in kilograms. Length, width, height, diameter in centimeters or meters, as appropriate. Volume in centimeters or meters, as appropriate. Center of gravity locations, when required.

(c) Diameters in centimeters or millimeters of inlet and outlet pipes, and pressure gauge connections.

(d) Rockwell C hardness of impeller shaft, spline hub and spline teeth.

(16) Pump reciprocating. The identical data listed under subparagraph (15).

(17) Block and tackle.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in kilograms. Length, width, height, and diameters in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate.

(c) Block material. Number of sheaves per block. Weight of complete assembly in kilograms, and safe working load in kilograms.

(d) Rope or tackle data including type and construction such as lay and number of strands. Diameter in centimeters, and length in centimeters or meters, as appropriate.

(e) Locking mechanism, if used.

(f) Verification that assembly components meet the following standards (appendix A) including: wire rope tackle blocks, MIL-B-24141; synthetic rope tackle block, MIL-B-24220; manila rope, MIL-T-R-605B; wire rope, MIL-R-15718; and nylon rope, MIL-R-17343.

(18) Hoists, chain and wire rope.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in kilograms. Length, width, height, diameter in centimeters or meters, as appropriate. Volume in cubic meters.

(c) Type hoist such as manual or driven, chain or rope. Lifting capacity in kilograms and range in meters. Hoisting speed in seconds. Type mounting and suspension method. Motor and controller characteristics, and type of gear. Limit devices and safety latches or locks, range of load hook and other nameplate data.

(d) Verification that assembly components meet the following standards (appendix A) including: motors NEMA-MG-1; controllers, NEMA-1C-1; and wire rope, Federal Specification RR-W-410.

(19) Cutters, floor mounted.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in kilograms. Length, width, height, diameter in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate. Center of gravity locations when required.

(c) Type of machine and work holddown such as mechanical or hydraulic.

(d) Length and width of work area, floor to table height, maximum use opening, distance between side housings, distance from holddown to knife edge, capacity or depth (thickness) of holddowns, length, width, height and thickness of cutting blades, length of shuttle feed loading table, and maximum distance between blade and work table in centimeters or meters, as appropriate.

(e) Motor-horsepower, flywheel revolutions per minute and strokes per minute.

(20) Sanders, belt or disk.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in grams or kilograms, as appropriate. Length, width, height, diameter in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate.

(c) Sanding surface flatness in millimeters or centimeters, as appropriate. Center of gravity locations, when required.

(21) Tool sets.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in grams or kilograms, as appropriate. Length, width, height, diameter in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate. Center of gravity locations, when required.

(c) Valve seat grinding stones. Cutting angle in mils or degrees. Minimum and maximum diameter of face in millimeters or centimeters, as appropriate.

(d) Cylinder hone maximum and minimum diameter in millimeters or centimeters, as appropriate.

(e) Piston ring cleaner blade thickness and diameter (range), piston ring compressor maximum and minimum diameter, and boring machine maximum and minimum diameter in millimeters or centimeters, as appropriate.

(f) Valve spring tension tester maximum spring height capacity, and cutting and flaring tool kit maximum and minimum capacity in centimeters.

(g) Gear puller range of jaws or attachment points, riveter kit size of jaws opening and depth, and hot plate work surface (heating) in centimeters.

(22) Tanks, petroleum liquid storage, fabric, collapsible. (Uncrated.)

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in kilograms. Length, width, height, when empty, in centimeters or meters, as appropriate. Fuel capacity in liters when filled at 25, 50, 75, and 100 percent of capacity.

(c) Overall diameter in meters, empty and filled. Locations and sizes of openings and connection points in centimeters.

(23) Tanks, liquid storage, metal.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in kilograms. Length, width, height, diameters in centimeters or meters, as appropriate. Capacity in liters when filled. Center of gravity location.

(24) Barges, self-propelled, and non-propelled.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Properly certified data from previous inspections or acceptance trials.

(c) Weight in kilograms or metric tons, as appropriate. Length, beam (molded) displacement, draft including forward, mean and aft, freeboard in centimeters or meters, as appropriate. Rated capacity of barge in metric tons. Center of gravity location.

(25) Boat, assault.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight (dry) in kilograms or metric tons, as appropriate, of the complete boat and all hardware. Rated capacity in kilograms or metric tons and number of personnel.

(c) Overall length, maximum width, maximum and reducible height in centimeters or meters, as appropriate. Center of gravity location.

(d) Design draft including forward and aft, and design freeboard in centimeters or meters, as appropriate.

(e) Number of attachments and location including towing eye, handles, lifting eyes, and cleats.

(f) Number and description of accessories including paddles, kits, engine, bilge pumps, horns, lights, anchors and compass.

(26) Boat, bridge erection.

(a) The applicable material characteristics data listed under paragraph 14d, and the applicable engine physical characteristics data listed under paragraph 6d.

(b) Gross weight in kilograms or metric tons. Length, maximum beam width, height maximum and reducible in meters. Capacity in kilograms or metric tons. Center of gravity locations.

(c) Draft, freeboard, in centimeters or meters, as appropriate. Crew space in cubic meters. Propeller, shafting reduction gear, engine, reverse gear, steering system, pump, blower, and anchor data.

(d) Rated speed of craft in knots. Fuel capacity in liters. Lights, attachments and accessories including handholds, ladders, seats, safety equipment, fire fighting equipment and kits.

(27) Boat, landing, inflatable.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight (dry) in kilograms of the complete boat and hardware. Center of gravity locations.

(c) Length overall, maximum width, height maximum and reducible in meters and volume in cubic meters.

(d) Design draft including forward and aft, design freeboard in centimeters or meters as appropriate. Rated capacity in number of personnel and kilograms.

(e) Number and location of attachments including towing eye, handles, lifting eyes, and number and description of paddles, kits, and motor.

(28) Water supply and treatment equipment.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in kilograms. Length, width, height, diameter in centimeters or meters. Volume in cubic centimeters or meters.

(29) Power generators. The identical data listed under subparagraph (28).

(30) Fuel monitoring and purity devices.

(a) The applicable material characteristics data listed under paragraph 14d.

(b) Weight in kilograms. Length and overall diameter in centimeters or meters, as appropriate. Diameters of inlet and outlet pipes, and pressure gauge connections in centimeters.

e. Analytical plan. See paragraph 5e.

14. General Supplies and Equipment.

a. Objective. See paragraph 5a.

b. Standards. See paragraph 5b. The applicable federal, military, and industrial standards listed under subparagraph d.

c. Method. See paragraph 5c.

d. Data required. The project engineer will obtain the following data:

(1) General.

(a) Code marking including nomenclature, model and serial number, size, cycle, systems, test site, and other information required for identification.

(b) Weight in grams or kilograms, as appropriate. Center of gravity locations, when required for the test item and non-attached components and ancillary equipment.

(c) Length, width, height, diameters, wall thickness in centimeters or meters, as appropriate. Volume in cubic centimeters or meters, as appropriate.

(d) Location and length, width, height in centimeters of door openings, storage compartments, drawers, spaces required by operator or passenger use. Description of overhanging or protruding components.

(e) The construction of the test item, its components and ancillary equipment, packing containers or crates, transit cases, material, waterproofing, finish, and color or shade of paint. The apparent quality of plating and workmanship including defects such as cold solder joints, and sticking or binding controls.

(f) Photographs, sketches, narrative descriptions of the test item, components and ancillary equipment, illustrating front, side, rear, top, and three-quarter front and rear views.

(2) Physical specifications.

(a) Carrying capacity such as liters, cubic meters, kilograms, metric tons, and number of personnel.

(b) Color as determined using American Society for Testing and Materials - Standards (ASTM-Standards) D1535 and D2244, as applicable (appendix A).

(c) Reflective properties as determined using ASTM-Standards E167.

(d) Maximum lifting height in centimeters or meters, as appropriate, minimum turning radius in centimeters, number of wheels, tracks, and skids.

(3) Material characteristics of paint, varnish, lacquer and related products. Data collected and recorded using the applicable ASTM-Standards (appendix A) as indicated below:

(a) Abrasion, D658 and D968; color difference measurements, D2244; gloss measurement, D527; rate of drying, D1359 and D1640; viscosity testing, D1545; and open cup flash point determinations, D56 and D1310.

(b) Closed cup flash point determinations, D1310; paint thickness measurement, D1186 and D1400; total water content, D95; infrared thermography, D168; and mildew, D1924.

(4) Material characteristics of rubber, carbon black and gaskets. Data collected and recorded using the applicable ASTM-Standards and MIL-P-3003G, Poncho, lightweight with hood (appendix A), as indicated below:

(a) Hardness, ASTM-D2240; hydrostatic bursting strength, D751; compression properties, D1055; softening point, D530; and thermoplasticity, D926.

(b) Water permeability, MIL-P-3003G.

(5) Material characteristics of metals or metallic items (ferrous and nonferrous). Data collected and recorded using the applicable ASTM-Standards, Fed-Std 1512, Metal Test Methods, and Society of Automotive Engineer (SAE) Paper No 660373 (appendix A) as indicated below:

(a) Hardness, ASTM-E140; infrared quantitative analysis, E168; ultraviolet qualitative analysis, E169; silicone content analysis E168; and ultrasonic detection of flaws, E114.

(b) X-ray detection of flaws, E94; thickness determinations, E252; and metal analysis, E45 and E112.

(c) Thickness determination using Fed-Std 151A, Method 521.1.

(d) Meseran surface analysis, SAE Paper No. 660373.

(6) Material characteristics of paper, packaging, cellulose, casein, flexible barrier materials, and leather. Data collected and recorded using the applicable ASTM-Standards, FS-KK-L-311a, Leather, Methods of Sampling and Testing, and FS-EE-M-45, Margarine (appendix A), as indicated below.

(a) Burst strength, ASTM-D2207 and D2529; instron ball burst D2207; external wetting, D724; puncture, D781; and time of wetting, D724.

(b) Water absorption, Method 8111; mildew resistance, Method 5011; and thickness, Method 1021 contained in FS-KK-L-311a.

(c) Rancidity, FS-EE-M-45.

(7) Material characteristics of bituminous materials for highway construction, waterproofing, and roofing. Data collected and recorded using the applicable ASTM-Standards (appendix A) as indicated below:

(a) Softening point, D36; viscosity, D88; and total water content, D95.

(b) Ultraviolet spectrophotometric analysis, E169; open and closed cup flash point, D1310; and infrared spectrophotometric analysis, E168.

(8) Material characteristics of structural sandwich construction: wood, aluminum, and paper boxes. Data collected and recorded using ASTM-Standards (appendix A).

(a) Resistance to accelerated aging, C481; and compressive properties, C365.

(b) Water absorption, D1714.

(9) Material characteristics of industrial water. Data collected and recorded using ASTM-Standards and Standard Methods for Examination of Water, Sewage, and Industrial Wastes (appendix A) as indicated below:

(a) Oxygen content, ASTM-D1589.

(b) Water examination, Standard Method for Examination of Water, Sewage and Industrial Wastes.

(10) Material characteristics of thermal insulation. Data collected and recorded using ASTM-Standards (appendix A) as follows: thermal transmittance, C236.

(11) Material characteristics of gaseous fuels, coal and coke. Data collected and recorded using ASTM-Standard (appendix A) as follows: calorific value of fuel using parr bomb calorimeter, D2015.

(12) Material characteristics of concrete and mineral aggregates. Data collected and recorded using ASTM-Standards (appendix A) as indicated below:

(a) Puncture, E154.

(b) Thickness, C29.

(13) Material characteristics of electrical insulating materials. Data collected and recorded using ASTM-Standards and SAE Paper No. 660373 (appendix A) as indicated below:

(a) Reid raper pressure, ASTM-D323; A.P.I. gravity, D287; viscosity, D88; acid-base number, D974; parr bomb sulfur content, D129; and mildew, D1924.

(b) Meseran surface analysis, SAE Paper No. 660373.

(14) Material characteristics of plastics. Data collected and recorded using ASTM-Standards and SAE Paper No. 660373 (appendix A) as indicated below:

(a) Elongation, ASTM-D674; coefficient of friction, D1894; spike penetration, D2289; brittleness, D1790; hardness, D1706 and D2240; hagemeter, D1003; flammability, D1692; compressive properties, D1929; optical test with vertometer, D637; glass, D523; mar resistance, D673; water absorption, D570; and mildew, D1924.

(b) Meseran surface analysis, SAE Paper No. 660373.

(15) Material characteristics of textile materials. Data collected and recorded using ASTM-Standards, American Association of Textile Chemists and Colorists (AATCC), Fed-Std-191, and FS-KK-L-311a (appendix A) as indicated below:

(a) Abrasion, ASTM-D1175; tear strength, D1424 and D2261; break strength D1682; elongation, D1682; air permeability, D737; stiffness, D1388; fiber identification, D276; fiber count, D276; flammability, D1230; colorfastness to weather-accelerated method, E42; thermal transmittance, D1518; water absorption, D583; and infrared thermography, D1518.

(b) Water removed by wringing, AATCC Procedure 107-1962; colorfastness to light-accelerated method, Procedure 16F-1964T; colorfastness to oxides of nitrogen, Procedure 75-1956; cracking, Procedure 8-1961; static charge, Procedure 76-1964; and launderometer, Procedure 61-1962.

(c) Resistance to accelerated aging, Fed-Std-191, Method 5512.2; adhesion of coating, Method 5970; blocking, Method 5651; sealed seam sealant - resistance to low temperature flexing, Method 5874; colorfastness and legibility of labels, Method 5651-1; weatherometer - for accelerated weathering, Method 5804-1, 5512.2; puncture, Method 5120; and water absorption, Method D570.

(d) Mildew resistance, FS-KK-L-311a, Method 5011.

(16) Material characteristics of petroleum products such as lubricants, liquid fuels and related products. Data collected and recorded using ASTM-Standards, Microchemist Journal Vol. 8, No. 4, American Association of Agricultural Chemists (AAOAC), MIL-F-8901A, Fed-Std-791A, and FS-KK-L-311a (appendix A) as indicated below:

(a) Spike penetration, ASTM-D1403; Karl Fischer water content, D1744; trace contaminants: D2276, D2391, D2407, and D893; metals content, D811 and D893; gum content of fuel, D381; reid vapor pressure, D323; H_2O saturation curve of fuel samples, D1094; A.P.I. gravity, D287; hydrocarbon diffusion, D2427; viscosity, D88; oxygen content, D1021; total water content, D95; infrared spectrophotometric content, E168; ultraviolet spectrophotometric content, E169; open and closed cup flash point, D56 and D1310; trace fluorescent, D1319; silicone content, E168; lead content, D526; gas chromatograph content, E260 and D2549; calorific valve of fuel - parr bomb calorimeter, D240; pentone insolubles, D893; acid-base number, D974; ashing, D189; and parr bomb sulphur content, D129.

(b) Carbon and hydrogen content, as described in pages 334-348, Microchemist Journal.

(c) Arsenic content, AAOAC - paragraph 24.001; and lead content, paragraph 24.045.

(d) Millipore solids content, MIL-F-8901A.

(e) Water separometer index, Fed-Std 791A - Method 3255-T; conradson carbon content, Method 5001.8; ashing, Method 5421.3.

(f) Mildew resistance, FS-KK-L-311e, Method 5011.

(17) Electrical characteristics.

(a) Type and size of wiring or cables, voltage and ampere rating, and number of wires or cables.

(b) Type of fuzes, size and number.

(c) Type of circuit breakers, size and number.

(d) Type of electrical grounding, and adequacy of electrical insulation including type and quantity.

(18) Chemical characteristics.

(a) Identify potentially hazardous materials such as acids, liquid fuels, and toxic fluids.

(b) Identify special storage conditions that are provided or are required, and any fungus proofing that is provided or is required.

(c) Identify special handling procedures or methods for chemical analysis of photograph developers, printing inks and liquid fluids.

e. Analytical plan. See paragraph 5e.

SECTION III
SUPPLEMENTARY INSTRUCTIONS

15. Safety. In addition to performing the actions described in TOP 1-2-506, the project engineer will insure that:

a. Test personnel are trained in and are familiar with the safety procedures prescribed in the test item equipment publications.

b. Safety procedures prescribed for handling and operating the test item are correct.

c. All safety features or devices of the test item are in fact required, are present, and function properly.

16. Preoperational Inspection. In addition to performing the actions described in TOP 1-2-505, the project engineer will delay the start of the ET until all of the items in the maintenance test package, including equipment publications, are present or an exception has been approved by TECOM.

Recommended changes to this publication should be forwarded to Commanding General, U. S. Army Test and Evaluation Command, ATTN: AMSTE-ME, Aberdeen Proving Ground, Maryland 21005. Technical information related to this publication may be obtained from the preparing activity, President, U. S. Army Field Artillery Board, ATTN: STEBA-PL, Fort Sill, Oklahoma 73503. Additional copies of this document are available from the Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A
REFERENCES

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2. AR 70-38, "Research, Development, Test, and Evaluation of Materiel for Extreme Climatic Conditions."

3. AR 310-25, "Dictionary of United States Army Terms."

4. AR 70-44, "Engineering for Transportability Program."

5. FED-STD 151A, "Metal Test Methods."

6. FED-STD 191, "Textile Test Methods."

7. FED-STD 791A, "Lubricants, Liquid Fuels and Related Products, Methods of Testing."

8. FS-EE-M-45, "Margarine."

9. FS-EE-KK-L-311A, "Leather, Methods of Sampling and Testing."

10. FS-RR-W-410, "Wire Rope."

11. MIL-STD 129, "Marking for Shipment and Storage."

12. MIL-STD 130, "Identification Marking of U. S. Military Property."

13. MIL-STD 709(1), "Ammunition Color Coding."

14. MIL-P-3003G, "Poncho, Lightweight with Hood."

15. MIL-F-8901A, "Filter/Separator, Aviation and Motor Fuel, Ground and Shipboard Use, Performance Requirements and Testing Procedures."

16. MIL-M-19590(-), "Marking of Commodities and Containers to Indicate Radioactive Material."

17. MIL-T-R-605B, "Manila Rope."

18. MIL-R-15718, "Wire Rope."

19. MIL-R-17343, "Nylon Rope."

20. MIL-B-24141, "Wire Rope Tackle Blocks."

21. MIL-B-24220, "Synthetic Rope Tackle Block."

22. NEMA-1C-1, "Controllers."

23. NEMA-MG-1, "Motors."

24. Department of Ordnance, "Elements of Armament Engineering," U. S. Military Academy, 1959-1960.

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30. "The Science of Precision Measurement," Do All Company, Des Plaines, Illinois, 1953 Rev.

31. "Meseran Surface Analysis," Society of Automotive Engineers, Paper 660373.

32. "Mechanics, A Textbook for Engineers," McGraw, 1950, Third Edition.

33. "Standard Methods for Examination of Water, Sewage, and Industrial Wastes," American Public Health Association.

34. Requirements Documents.

35. Test Directive.

36. Safety Release.

NOTE: Additional references not referenced within this TOP which may be of value to specific ET agencies are listed at appendix F.

APPENDIX B
CENTER OF GRAVITY DETERMINATIONS

1. Introduction. The longitudinal and lateral (vertical, when required) center of gravity location for all test items, subsystems, and ancillary equipment must be determined when they are designated for air portability and air drop tests. Center of gravity locations on heavy combat and construction equipment provide guidance for handling this type of equipment during maintenance shop servicing, rail and other surface transport means, and in loading personnel and cargo in vehicles which have a transport capability. Additionally, the center of gravity location of projectiles aids in determining the projectile aerodynamic characteristics. The various basic methods and procedures for determining the center of gravity locations are described in the following paragraphs.

2. Weighing Method. The weighing method of determining longitudinal center of gravity location of a vehicle is illustrated at figure B-1. Lateral center of gravity location of the vehicle can be determined, when required, simply by positioning the vehicle so that two side wheels are supported by the scales platform and the other two side wheels are supported by the floor. Weights and dimensions would then be used in the same equation and center of gravity location calculated. The method illustrated in figure B-1 may be applied to any item; however, the points of support (rear and front wheels in contact with floor and scales platform in figure B-1) must be pivotal points. Pivotal points for items without wheels can be provided through use of round metal pipes or rods as support points.

3. Balancing Method. The balancing method of determining longitudinal center of gravity location is illustrated at figure B-2. This method may be applied to any item having a flat, hard, and smooth bottom surface such as equipment or supplies rigged on a platform for airdrop. When such an item is positioned on a metal pipe or rod to obtain a balanced condition, the center of gravity lies directly above the balance point. Top heavy items should be rotated 90° and balanced again to locate the center of gravity.

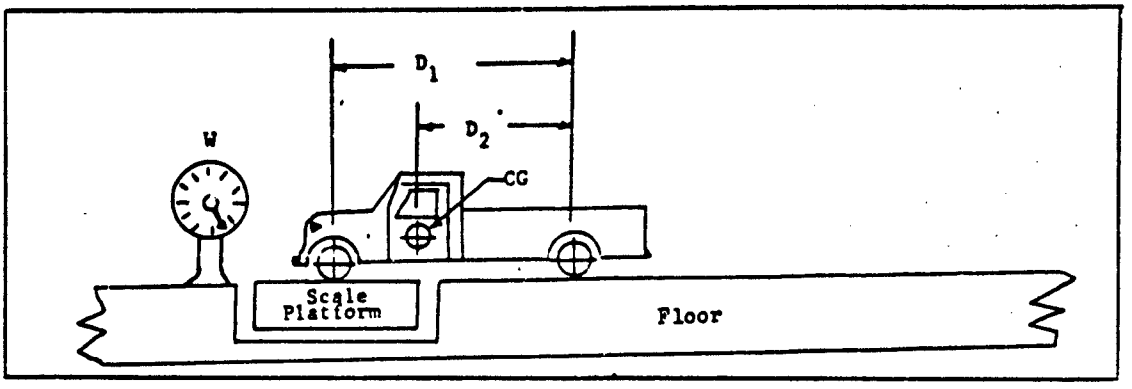

Figure B-1. Center of Gravity Horizontal Determination (Weighing Method)

W_t = Total Item Weight in Kilograms

W = Weight as indicated by scales in sketch

Then: $D_1W = D_2W_t$

Or: $D_2 = \frac{D_1W}{W_t}$ = Distance Forward from the Rear Axle where Center of Gravity is located.

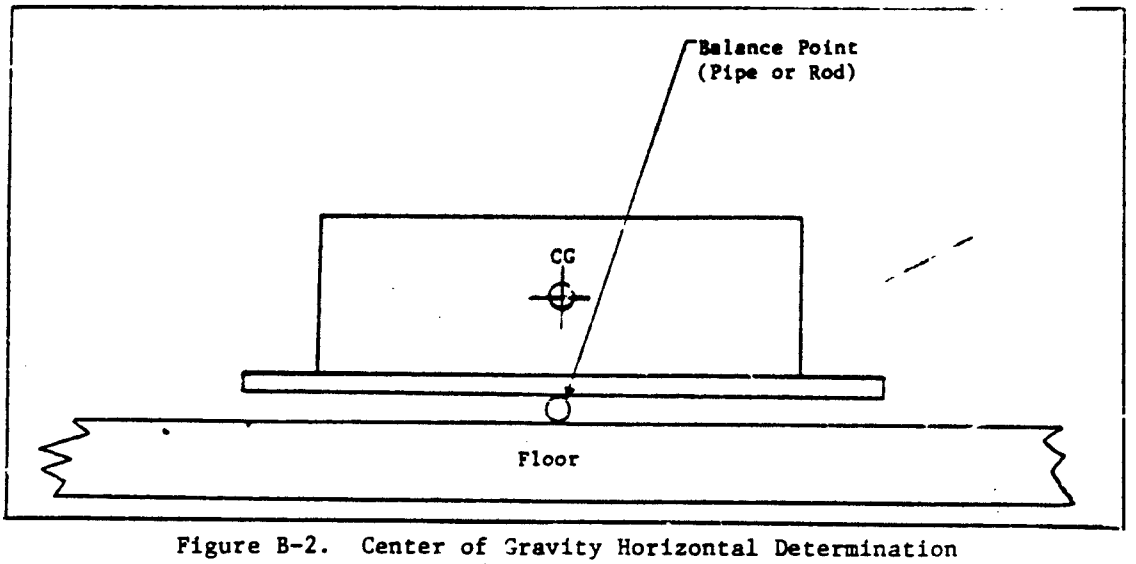

Figure B-2. Center of Gravity Horizontal Determination (Balancing Method)

4. Suspension Method. The suspension method of determining longitudinal and vertical center of gravity location is illustrated at figure B-3. This method also applies to test items which are not skid mounted or when the weight of sling cables is negligible when compared to the weight of such test items as tracked armored and self-propelled field artillery weapons. The center of gravity location is determined as follows:

a. When the test item is a heavy equipment such as a tracked armored or self-propelled field artillery weapon, the following test preparations should be performed. Verify that the test item is in a ready-service condition which includes:

(1) Fully serviced including fuel, oil, and water.

(2) Auxiliary equipment including weapons, ammunition and communication equipment has been installed or stowed.

(3) Cargo and personnel carrying vehicles should be fully loaded utilizing simulated loads of equivalent weight and volume.

(4) Establish location of test item and theodolite or transit in relation to the predetermined reference points on the test item.

(5) Position the theodolite broadside to and at an effective distance from the test item.

(6) Attach a marking panel to the side of the test item facing the theodolite or transit. The marking panel is used only when the shape is irregular and it is impractical to apply projected lines on the test item.

b. The following procedures for determination of center of gravity location should be used whether the test item is a tracked vehicle or skid mounted equipment and supplies.

(1) Position the overhead crane using the theodolite or transit.

(2) Attach the lifting cables to the lifting hooks on the test item or skid.

(3) Suspend the test item, as illustrated for position A in figure B-3, from the crane using unequal length sling cables to achieve the optimum suspension angle of 45° and maintain the suspended load at 90° to the sighting theodolite or transit.

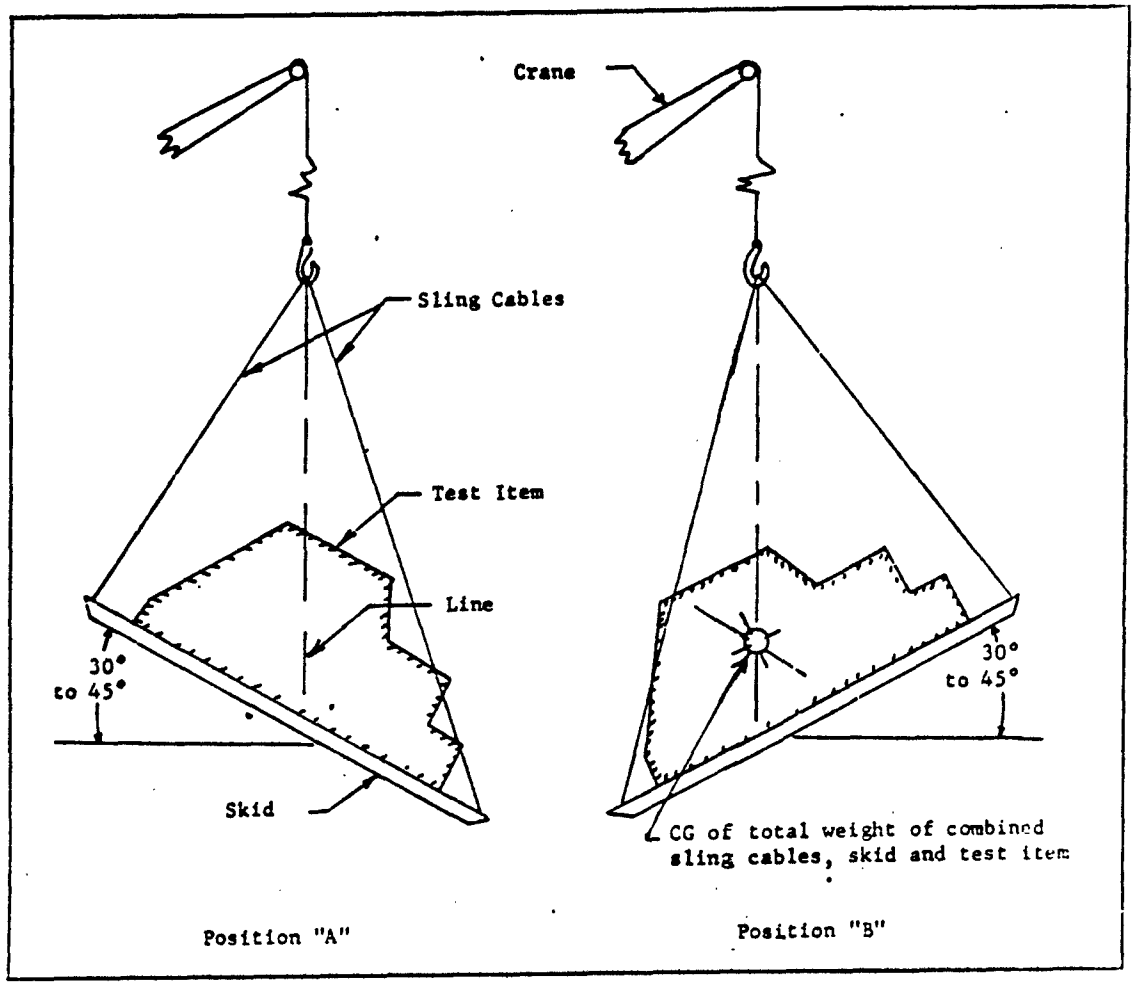

Figure B-3. Center of Gravity Horizontal and Vertical Determination (Suspension Method)

(4) Project a vertical line from the center of the load hook pivot to the marking panel on the test item using the theodolite or transit to determine the projection. Insure that the vertical plane of the test item longitudinal axis is normal to the vertical plane described by the theodolite or transit sighting scope.

(5) Inscribe the projected line on the test item or marking panel.

(6) Repeat steps (1) through (5) with sling cables interchanged as illustrated for position B in figure B-3.

(7) The center of gravity location will be at the exact intersection of the projected lines for the total weight of combined sling cables, test item and skid.

(8) When predetermined reference points on the test item are set forth by the test directive or test plan, measure and record:

(a) Vertical distance in centimeters between the intersection of the inscribed lines and the horizontal reference line.

(b) Horizontal distance in centimeters between the intersection of the inscribed lines and the vertical reference line.

(9) In addition to the data recorded in (8), record the following for each test item:

(a) Nomenclature, serial number and model number.

(b) Load condition (ready-service, full-load).

(c) Total weight in kilograms.

(d) Date of test.

c. Error factors.

(1) When the test item is a vehicle, consideration must be given to the fact that most vehicles have a spring suspension system. In a normal position on the ground the vehicle weight compresses the springs, and when the vehicle is suspended from a crane, a considerable difference in weight distribution could have an appreciable effect on the center of gravity location. Therefore, methods for tying or blocking the springs may be required.

(2) The suspension angle will cause the shifting of fluids such as fuel, oil, and water within a vehicle. This may cause a difference in weight distribution which may have to be considered. Insuring that tanks for fuel and other liquids are filled to 75% of capacity will minimize the weight variations.

5. Reaction Method. The reaction method of determining center of gravity location is illustrated at figure B-4. This method is used when the equipment required to determine the center of gravity location by the suspension method, paragraph 4, is of inadequate capacity for the test item. The reaction method is based on the fact that when a body is in static equilibrium, the sum of the moments about an axis of rotation is zero. To provide the axis of rotation, one end of a test item is suspended so that it pivots about a knife edge attached at the underside of the opposite end of the item. The center of gravity location is determined as follows:

a. Attach a knife edge to the underside of the test item as shown in figure B-4.

b. Position the test item so that the knife edge rests on the pivot block.

c. Attach the weighing cell and mounting hardware to the test item.

d. Suspend the test item at the weighing cell end so that the knife edge pivots on the block. The test item must be free from motion while balanced on the knife edge and the lifting force must act in a vertical direction as shown in figure B-4.

e. Measure and record:

(1) Horizontal distance between the axis of rotation and the line of action of the lifting force in centimeters.

(2) Lifting force required to balance the test item on the knife edge as measured by the weighing cell in kilograms.

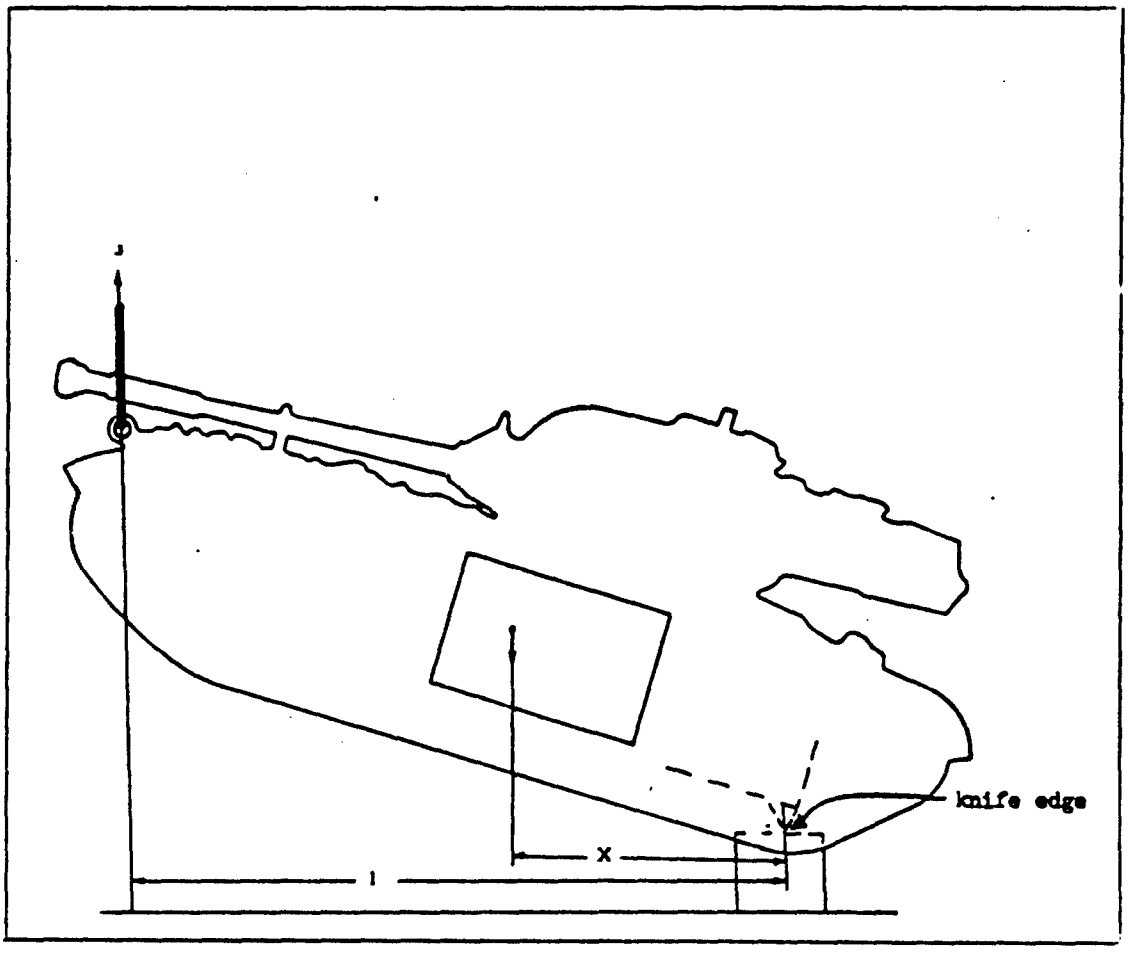

Figure 4. Reaction Method for Determining the Center of Gravity

f. Compute and record the horizontal distance between the axis of rotation and the center of gravity from the following equation:

$$\bar{X} = \frac{sl}{W}$$

Where: $\bar{X}$ = Horizontal distance between the axis of rotation and the center of gravity in centimeters.

s = Force required to balance the test item on the knife edge, in kilograms.

l = Horizontal distance between the axis of rotation and the lifting force in centimeters.

W = Weight of the test item in kilograms.

g. Project a vertical line, at the computed distance ($\bar{X}$) from the axis of rotation to the marking panel (use theodolite or transit to determine the projection). The vertical plane of the test item longitudinal axis must be normal to the vertical plane described by the theodolite or transit sighting scope.

h. Inscribe the projected line on the marking panel or test item.

i. Repeat steps a through h with the axis of rotation at the opposite end of the test item. The inscribed lines must intersect on the marking panel or test item since the intersection of the inscribed lines determines the center of gravity location.

j. Measure and record:

(1) Vertical distance between the intersection of the inscribed lines and a horizontal reference line in centimeters.

(2) Horizontal distance between the intersection of the inscribed lines and a vertical reference line in centimeters.

k. The reference lines in subparagraph j are located by theodolite or transit from predetermined reference points on the test item specified in the test directive or test plan for the specific test item.

1. Error factors. The error factors discussed under paragraph 4c, 'Suspension Method" are also true for the reaction method. Additionally, the reaction method is dependent on the solution of an equation in which quantitative measurement must be made. The length measurements in particular provide additional probability of error since the horizontal distances to the projected lines must be measured precisely.

6. Projectile Center of Gravity Location. The center of gravity location of a projectile may be determined by the projectile balancing methods or by the beam scale method. The balancing methods are used to determine the center of gravity location of projectiles that are handled manually. The beam scale method is used to determine the center of gravity location of projectiles that cannot be readily handled manually. The beam scale method should also be used to determine the center of gravity locations of smaller projectiles and bullets, provided the ratio of the projectile weight is such that the scale used has the sensitivity to detect small changes in the projectile position within the apparatus. The beam scale method provides the most practical technique for determining the center of gravity location of small arms bullets such as the caliber .22, .30, .50, and 7.62 millimeter, where an analytical balance is employed. The projectile weight to apparatus weight ratio and the scale sensitivity parameters can be verified by using an object of regular geometry and of approximately the same weight as the test item prior to test determination of center of gravity location. The various balancing methods and the beam scale method and procedures for the determination of center of gravity location are described in the following subparagraphs.

a. Trough balancing method. The center of gravity trough, illustrated at figure B-5, consists of a trough with two adjustable knife-edge trunnions and counterweights at each end, a level vial, graduated scale, and parallel blocks with "V" bearings. To determine the center of gravity location of a projectile, the knife-edge trunnions are positioned in the "V" bearings and the trough is leveled by the counterweights. The projectile is positioned in the trough, as required, until the trough is again level. When a straight edge is placed across the base of the projectile, the location of the center of gravity, with respect to the base, can be directly read on the graduated scale. This method requires two trough sizes for projectiles in the 37 to 155 millimeter range.

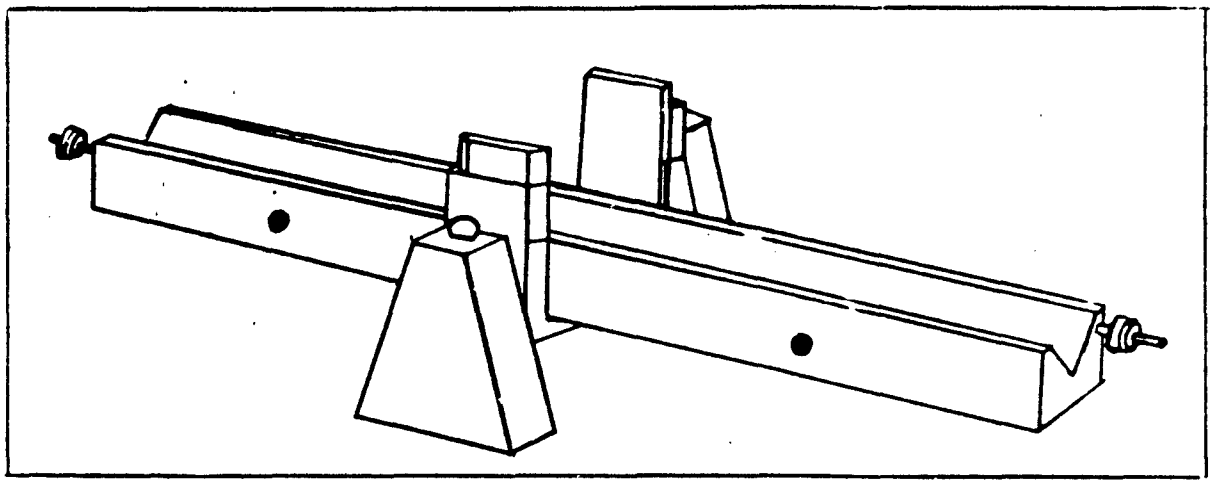

Figure B-5. Center of Gravity Trough

b. Yoke balancing method. The yoke balancing device, illustrated at figure B-6, consists of a yoke assembly with two knife-edge trunnions, an adjustable counterweight at the bottom and a pointer at the top. The method of balancing with this device is adaptable to all projectiles up to 155 millimeter, however, several different sizes of apparatus are required. Figure B-7 illustrates the yoke assembly only which is also used as a holder in moment of inertia measurements discussed in appendix C. To determine the center of gravity location of a projectile, the yoke assembly is placed in the support assembly with the pointer in front of the attached weighing scale. The weighing scale has evenly divided units of measure. The projectile is placed in the yoke assembly and clamped near the estimated center of gravity location as shown in figure B-8. The deflection of the pointer on the scale is recorded and the distance from the face of the clamp holder to the projectile base is measured and recorded. The projectile is then shifted in the yoke and another series of deflection and clamp to base measurements are recorded. The deflection and measurement process is repeated until at least three positions have been recorded. The distances from the holder face to the base are adjusted to reflect the distance from the knife-edge trunnions to the base and these values are plotted against deflections as shown in figure B-9. The point at which the plotted curve intersects the zero deflection line is the distance of the center of gravity from the base of the projectile. The accuracy of results is dependent upon the accuracy of the measurements. The distance from the base should be measured to at least three equally spaced positions around the yoke assembly. Utilizing a height gauge, with the projectile standing upright on a surface plate, will provide an accurate series of measurements.

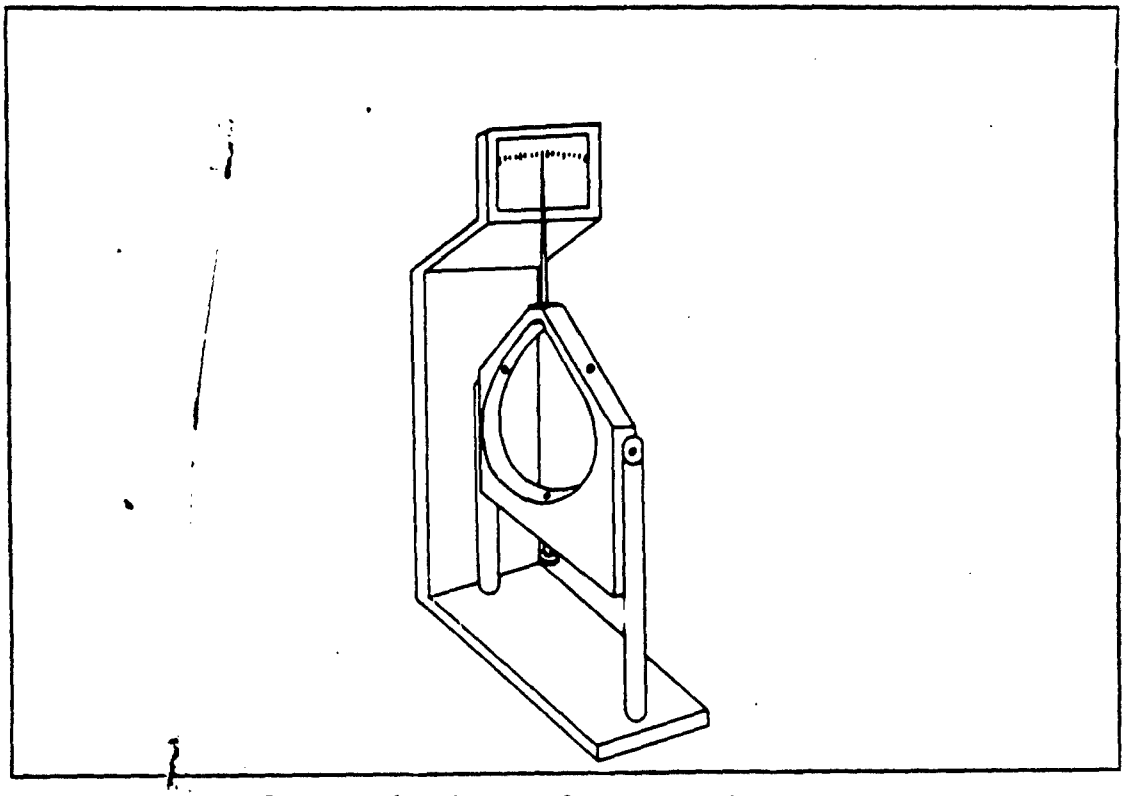

Figure B-6. Center of Gravity Yoke Device

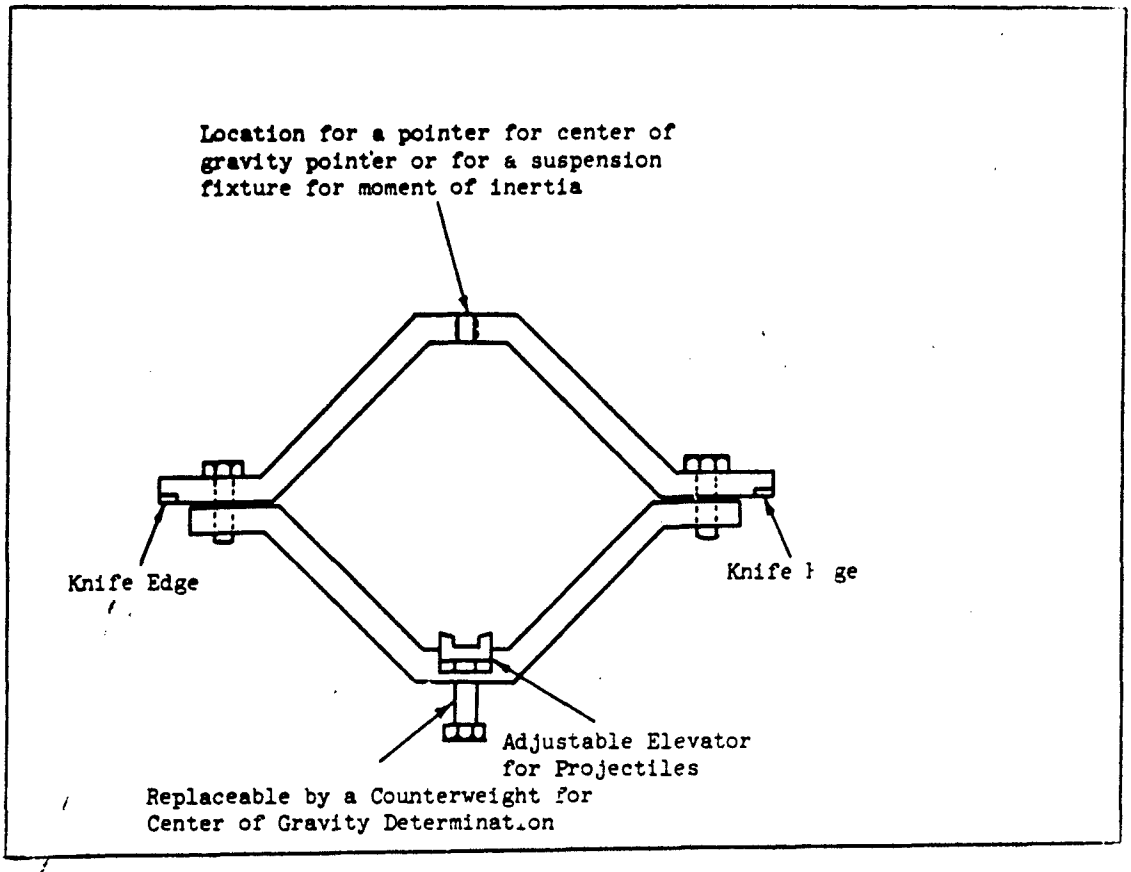

Figure B-7. Center of Gravity Yoke Assembly

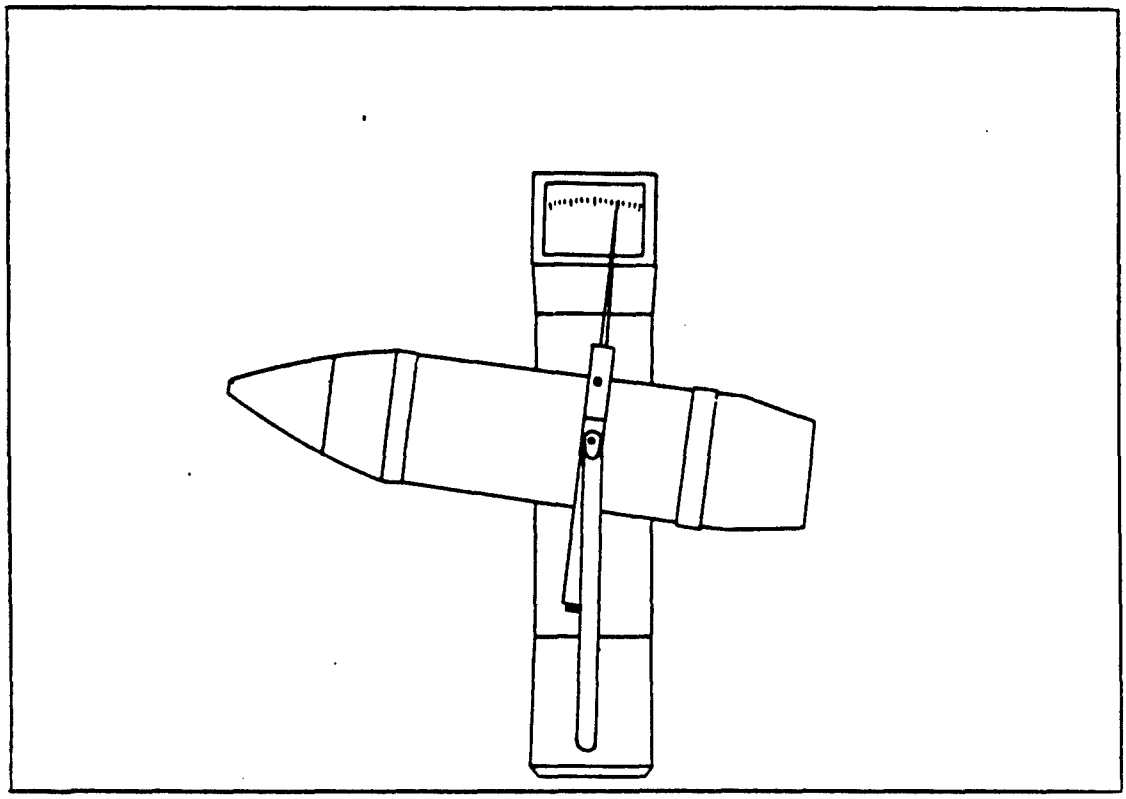

Figure B-8. Center of Gravity Yoke Assembly with Projectile in Balancing Position

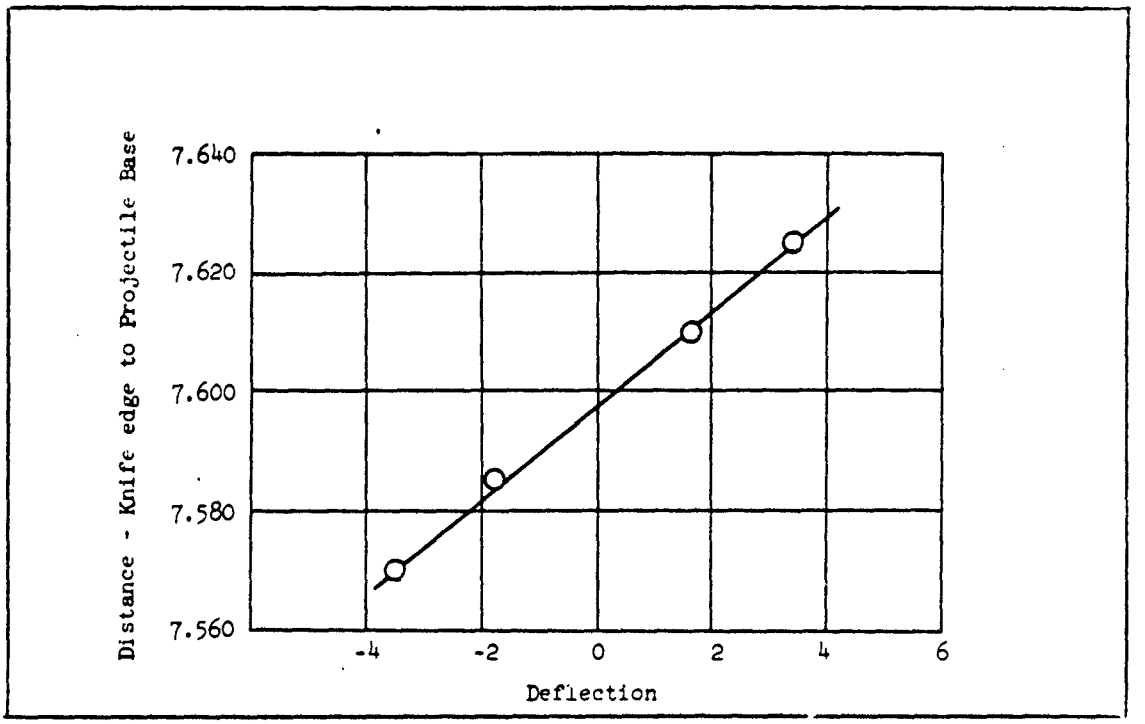

Figure B-9. Typical Center of Gravity Location Plot for 105mm Projectile

c. Beam scale method. The beam scale is a beam or trough supported at each end by two line contact devices as illustrated at figure B-10. One end of the beam has a vertical stop, the inside edge is in the same plane as the line of contact of the supporting iron and a leveling support for the angle iron. Angle irons with machined radii at the supporting edge provide the necessary supports. Sharp knife edges are not practical for support due to the weight involved. The other end of the beam is supported by the angle iron placed on a platform scale. Figure B-10 illustrates the projectile in position on a leveled beam with its base against the stop. To determine the center of gravity location of a projectile, the center of gravity location of the beam must first be determined. The following steps should be followed:

(1) Determine the weight of the beam.

(2) Determine the distance between the support edges A and B.

(3) With the beam only in position on the supports, determine the weight of the beam recorded on the platform scale.

(4) Determine the center of gravity location of the beam using the following equation:

$$L_1 = \frac{L_2 W_3}{W_1}$$

Where: L_1 = distance of the cg of the beam from support B.

L_2 = distance between supports A and B.

W_1 = weight of the beam.

W_3 = scale reading with the beam only.

(5) The center of gravity location of the projectile is determined by placing it in position on the beam scale device, leveling the beam, recording the weight indicated on the platform scale and using the following equation:

$$L_0 = \frac{L_2 W_2 - L_1 W_1}{W_0}$$

Where: L_0 = distance of the projectile cg from its base.

L_1 = distance of the beam cg from support B.

L_2 = distance between supports A and B.

W_0 = weight of projectile.

W_1 = weight of beam.

W_2 = scale reading with projectile in position $(W_0 + W_1)$.

The accuracy of the center of gravity location is dependent on the measurement distance L_2 and must be made with care and precision.

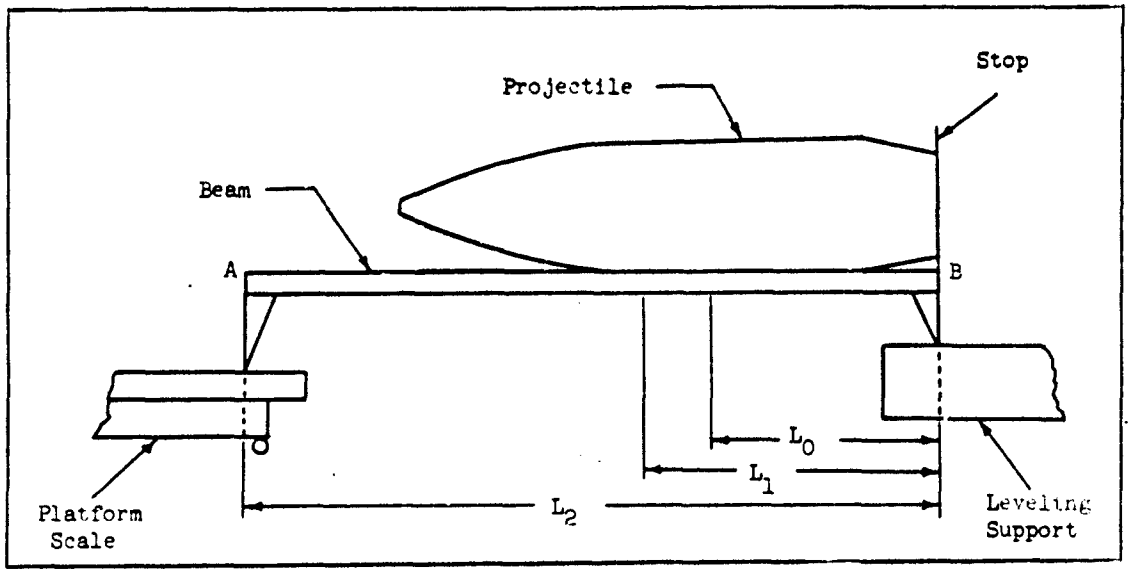

Figure B-10. Beam Scale Apparatus for Determining the Center of Gravity of Projectiles

APPENDIX C
MOMENTS OF INERTIA DETERMINATIONS

1. Introduction.

a. Moment of inertia is a measure of the effectiveness of mass in rotation. If a projectile is a solid of revolution it has two principal moments of inertia:

(1) Axial moment of inertia which is the moment about its longitudinal exis.

(2) Transverse moment of inertia which is the moment about an axis through the center of gravity perpendicular to the longitudinal axis.

b. Theoretically, only the transverse moment of inertia is required to be determined for nonspinning, fin-stabilized projectiles. Experience shows that most fin-stabilized projectiles do spin, therefore, their axial moment of inertia must also be determined.

c. To determine the moments of inertia of projectiles the torsion pendulum is employed. This appendix describes the setup and use of the torsion pendulum in the moment of inertia determinations. Two methods are described involving the same principles but different mathematics. The two methods are:

(1) Standard method.

(2) Special method.

d. Either of the above methods can be used to determine the moments of inertia of projectiles of all sizes. The standard method relies on test personnel to trigger a timing device during visual sighting. The special method involves the use of a photoelectric cell to trigger a timing device which eliminates the human error inherent in the standard method. When a high degree of accuracy is desired, then the special method should be used since the moments of inertia of projectiles can be determined to an accuracy of one-tenth of one percent. Both methods are described in the following paragraphs.

2. Standard Method.

a. The standard method for determining the moments of inertia of projectiles is a torsion pendulum method which can be used with all sizes of projectiles. The suspension is a straight length of tungsten wire between the top and bottom fixtures as illustrated at figure C-1. The top fixture fits into a rigidly held level plate. The projectile holder is attached to the fixture at the bottom end of the wire.

b. Two types of projectile holders are used in making axial moment of inertia measurements as described below:

(1) One type is a metal cup which fits over the projectile base. It is slotted for finned missiles and held in place by set screws. The projectile is normally suspended nose down. However, when the projectile is of such shape that a base cup holder is impractical, a longer cup holder can be fitted over the nose of the projectile and tightened against the body of the projectile and then suspended nose down.

(2) The other type is a dummy fuze inserted into the fuze cavity when the metal cup holder for the nose or base cannot be used. This configuration must be symmetrical and the dummy fuze centered as the holder in the projectile to determine the true axial moment of inertia. When the moment of inertia is to be determined for a projectile complete with fuze under this method, the regular fuze moment of inertia is determined independently. A projectile in position with the metal cup attached to the base is illustrated at figure C-2.

c. A projectile in position for determining its transverse moment of inertia is illustrated at figure C-3. The transverse projectile holders are usually of a double "V" type which may be modified to be adapted to unusual shapes. This same projectile holder may be used in the determination of center of gravity location as illustrated in figure B-7, appendix B. When this device is used as a moment of inertia holder, the projectile is placed in the holder so that the knife-edges are in line with the center of gravity location and the clamping devices are tightened and the holder then is attached to the suspension system.

(1) When the projectile holder is attached to the suspension wire for either axial or transverse measurement, the pendulum is brought to rest and a chalk mark placed on the projectile. The entire assembly is steadied to eliminate all vibrations or swinging motions.

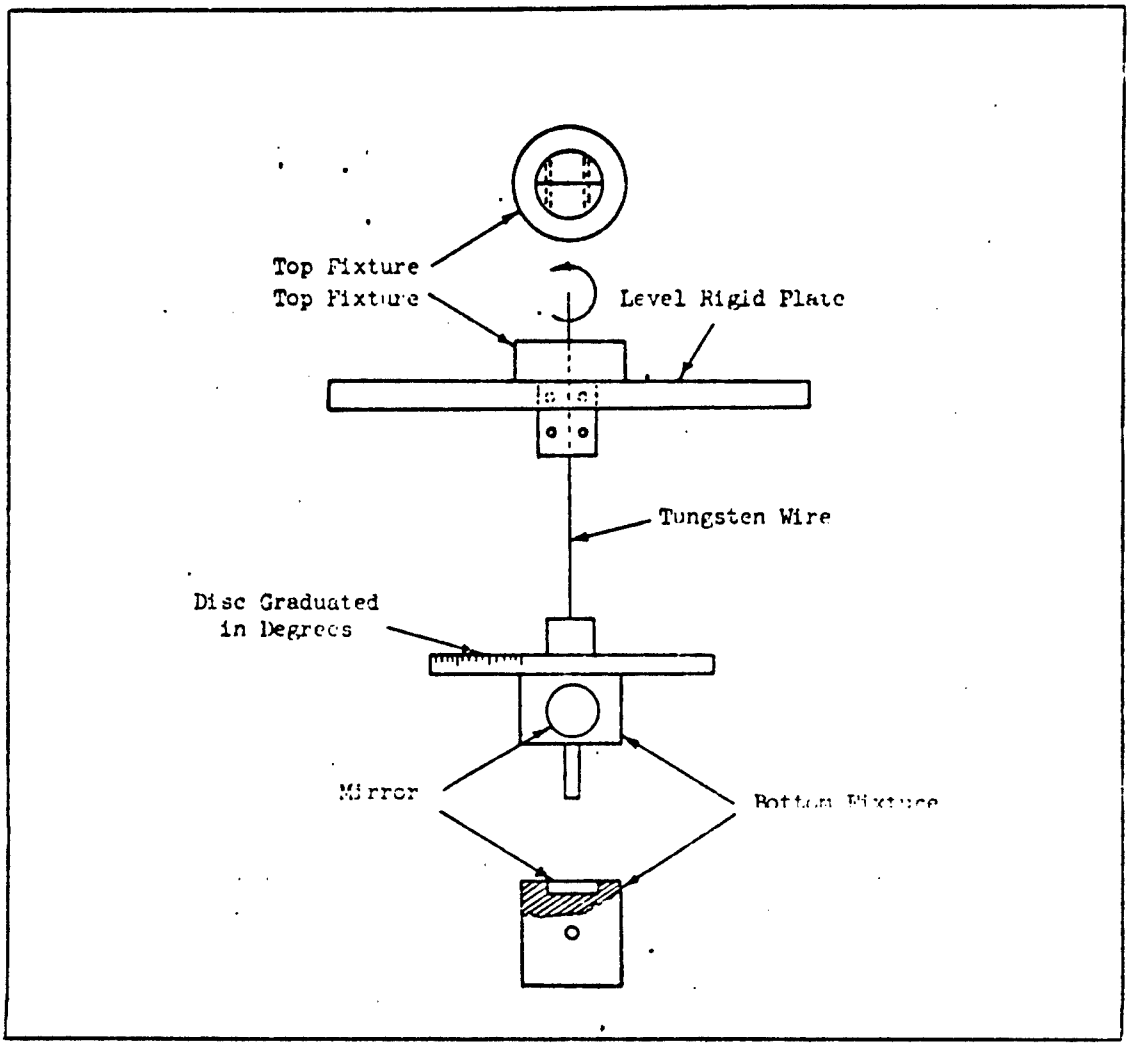

Figure C-1. Torsion Pendulum Components

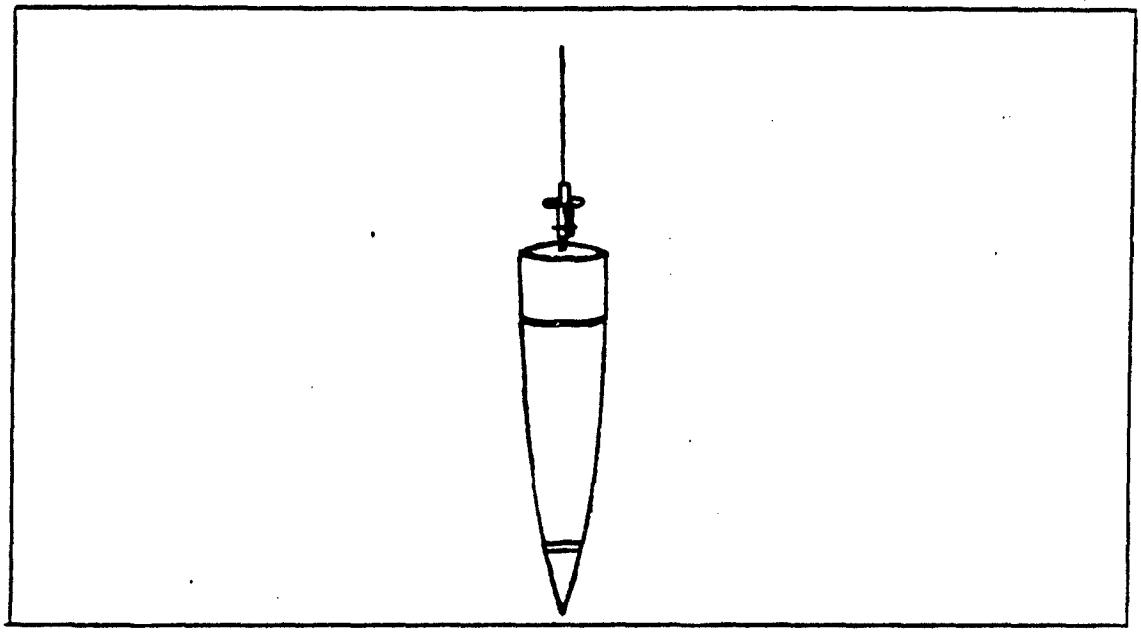

Figure C-2. Projectile Suspended Nose Down - Base Cup Method

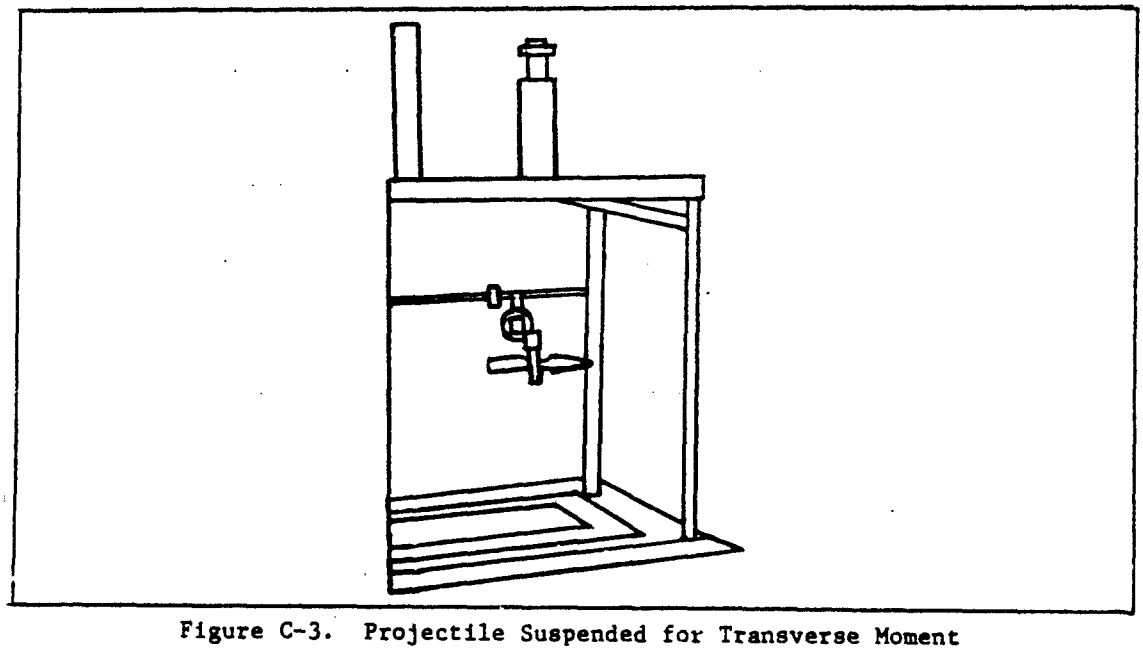

Figure C-3. Projectile Suspended for Transverse Moment of Inertia Determination

(2) The projectile is placed in torsional oscillation by twisting the top fixture and releasing it to allow it to return to the "zero" position. The suspension assembly will oscillate and the oscillation angle should approximate 90°, 45° in each direction. The optimum half amplitude of 45° is required for the following reasons:

(a) The same amplitude is used from projectile-to-projectile to obtain the best comparable results.

(b) Extensive experimentation has shown that results approach the theoretical calculated values with this half-amplitude.

(3) The test operator will view the projectile through a telescope and start a stop watch as the chalk mark first passes the cross hairs of the telescope. When the required number of oscillations are completed, the stop watch is stopped as the chalk mark passes the cross hairs.

(4) To determine the axial moment of inertia a minimum of five complete periods are timed by a stop watch. To determine transverse moment of inertia a minimum of three complete periods are timed by a stop watch.

d. To obtain the moments of inertia of projectiles, the wire constant of the torsion pendulum and the moment of inertia of the holding device must be determined. The values are obtained by the utilization of test masses as illustrated at figure C-4.

(1) The two calibration masses are required for the axial and transverse determination of moments of inertia. The masses are of regular geometric shape, usually cylinders either solid or hollow, superimposed on each other. Their moments of inertia may be easily calculated.

(2) The calibration masses must be designed so that the moment of inertia is bracketed by their moments in each case. The weights of the masses must be within five percent of the projectile weight to eliminate effects due to weight variations on the suspension wire. The calibration masses must fit the same holder as the projectile in each case.

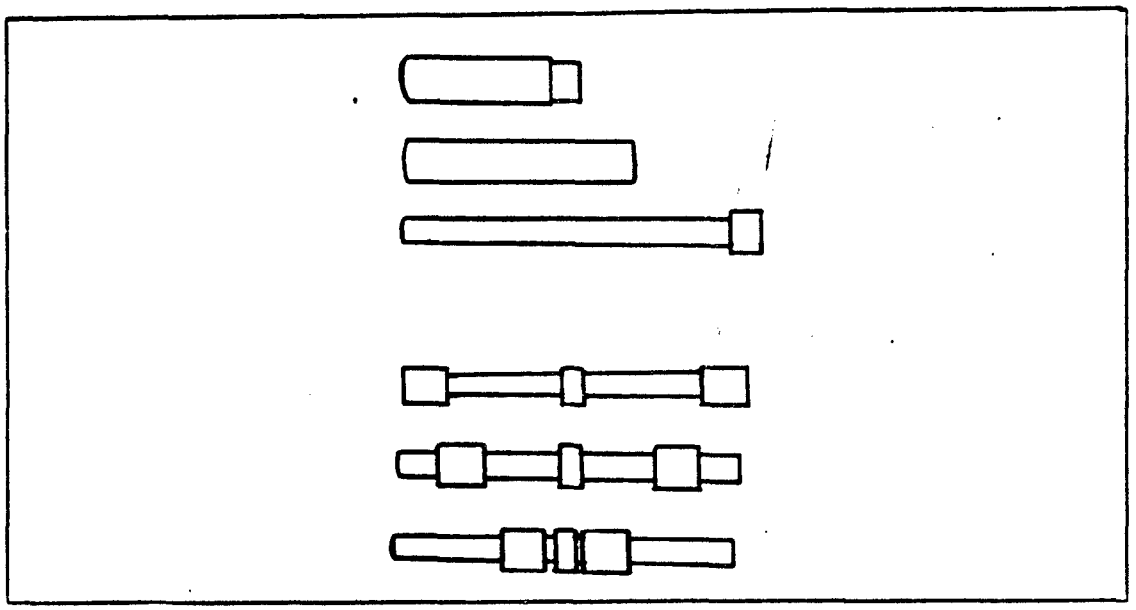

Figure C-4. Calibration Mass Sets

(3) The equation for computing either the axial or transverse moments of inertia of a projectile is as follows:

$$I = k\,T^2 - i$$

I = moment of inertia of the projectile
k = torsional constant of the suspension wire
T = average period of oscillation
i = moment of inertia of the holder

In order to obtain the values for k and i two equations must be solved (one for each test mass) as given below:

$$I_1 = kT_1^2 - i \text{ and}$$

$$I_2 = kT_2^2 - i$$

Where: I_1 = moment of inertia of the larger mass.

I_2 = moment of inertia of the smaller mass.

Solving the above equations for k and i produces the following:

$$k = \frac{I_1 - I_2}{T_1^2 - T_2^2}$$

and,

$$i = \frac{T_2^2 I_1 - T_1^2 I_2}{T_1^2 - T_2^2}$$

(a) Experience has shown that the "constants" k and i, remain constant for only a limited period of time. Reasons for this change of values are not clear. However, a partial answer is that changes in temperature result in changes in the wire constant. Temperature changes also cause dimensional changes and, therefore, cause some change in the weight distribution of the test masses. The moments of inertia for a given test mass at one temperature will differ from its moment of inertia at another temperature.

(b) In the equations used to determine k and i, the moments of inertia of the test masses are used as constants. Because of the form of the equation used to determine their moments the errors of the system seem to be associated with the value of i. The procedure results in a measurement accuracy of about one percent.

3. Special Method.

a. A special method for determining moments of inertia to an accuracy of 0.1 percent can be employed utilizing special techniques, additional equipment, and a different mathematical treatment. In this method, the bottom fixture illustrated in figure C-1 serves to trigger the timing device, hold the projectile, and regulate the amplitude of oscillation.

b. For triggering purposes, a front surface, plane mirror is set into one face of the fixture. At a distance of approximately 18 inches (depending on the lens system) a photoelectric circuit is set up. Included in this circuit is a light source whose beam is focused on the mirror. As the pendulum oscillates the beam is reflected to the photocell, which, in turn, triggers an electric cycle counter. In the trigger circuit there is a relay mechanism that can be preset so that only a certain number of oscillations can be timed. If the relay device is present, then the cycle counter is started when the light first strikes the photocell and stops after the required number of oscillations have occurred.

c. The bottom fixture is threaded to permit easy attachment of the projectile holders to the suspension system. The fixture has a disc that is graduated in degrees which is used as an aid in maintaining the correct amplitude of oscillation. To reduce measurement errors, the entire suspension system must be enclosed or located in a position where air drafts cannot influence the oscillation or set up a secondary swinging motion.

d. After the projectile is attached to the suspension system, the pendulum is brought to rest with the mirror in line with the photocell. The system must be steadied to prevent swinging or vibration. To obtain consistent results the amplitudes for all projectile tests must be equal. The test results are most consistent when the half-amplitudes are 45°.

e. From a mathematical standpoint, two test masses and two equations are required for solution, but greater accuracy can be obtained by using three masses. If the estimated moment of inertia of the projectile is designated as I the moments of the three test masses should approximate $\frac{2I}{3}$, I, and $\frac{4I}{3}$ and their weights should be within five percent of the projectile weight. Three equations with two unknowns can be set up and a solution obtained by the method of least squares. The equation of the standard method is modified to the following form to facilitate solution:

$$\bar{i} + \bar{k}\, I = T^2$$

Where: $\bar{i} = \frac{i}{k}$

$\bar{k} = \frac{1}{k}$

f. The moments of inertia for the test masses are computed from the relationships given under the discussion of the standard method for solid and hollow cylinders. The method of least squares is a common statistical method.

APPENDIX D
SPECIAL MEASUREMENTS

1. Introduction.

a. There are numerous qualitative and quantitative methods for determining the quality of surfaces. Not all types are discussed in this document since projectile surface finish determinations are not always required and all of the methods do not seem practical for this purpose. Two of the qualitative methods which are most adaptable are:

(1) Surface comparator blocks.

(2) Faxfilm surface comparator.

b. Either method seems equally valid since a visual comparison must be made and the surface finish to be evaluated is matched to a known finish. The comparator block method offers the additional capability of matching a surface through the sense of touch.

c. Qualitative methods are used whenever an approximate determination of surface finish is required. Of the two methods discussed here the comparator blocks offer the advantages of economy and ease of use since the Faxfilm system requires rather elaborate projection equipment. Faxfilm usage, most probably, would be governed by its availability.

d. If a more reliable determination of surface finish is desired, then a quantitative surface evaluation can be made. Two quantitative measurement systems are discussed in this document. They are very similar and are identified as:

(1) Brush surface analyzer.

(2) Profilometer.

e. These instruments employ a point or stylus to investigate surface irregularities, in the same manner that a phonograph stylus picks up the irregularities from the grooves of a record. These direct-measuring instruments magnify the irregularities and record them for later evaluation.

f. While these instruments are able to directly investigate the surface of a projectile they must be used properly which means that the operator must have achieved a certain amount of familiarity with the instrument. While the two systems are practically equal both offer the disadvantage of being expensive since amplifying and recording equipment must accompany the detector section. Presumably, the availability of either system would determine the ultimate choice if a quantitative measure of surface finish is required.

2. General.

a. The measurement of surface roughness is not a routine requirement for projectile examination and testing. However, experimental work on projectiles may require that the surface finish be gauged since it affects the aerodynamic performance of projectiles, especially with respect to "drag". Effects of finish on other specific aerodynamic characteristics are conjectural, so, no definite gauging criteria have been established.

b. To measure the characteristics of a surface it is usually necessary to have a reference plane to which these measurements can be referred. This reference plane, called the nominal surface, is the two-dimensional separation boundary between a theoretically perfect surface and the surrounding medium. It corresponds to the plane of an object line on a drawing. Departures from the nominal, or theoretically perfect surface, are called surface deviations and take forms such as flaws, waviness and roughness.

c. Roughness measurements are taken across a surface in the direction which indicates the greatest irregularity, unless otherwise specified. Surface roughness is usually specified as a number representing the root-mean-square (RMS) or arithmetical average expressed in microinches. Discussions of RMS averaging and other statistical treatment of surface measurements may be found in "Precision Measurement in the Metalworking Industry" and in "The Science of Precision Measurement" (appendix A).

3. Surface Comparator Blocks.

a. Where a visual and tactile comparison is made of a surface, comparator blocks can be used effectively. These blocks are furnished in sets of varying numbers with each block having its degree of roughness identified in microns RMS. Typical finishes represented are ground, milled, turned, shaped, broached and lapped.

b. When making comparisons with the standard roughness blocks the specimen whose surface pattern most nearly matches that of the test projectile is selected. Comparison is made by sight and feel. By running a fingernail, or the tip of a finger, over the surfaces the degree of roughness can be matched to the standard block.

4. Faxfilm Surface Comparator.

a. Faxfilm is a method of surface examination which employs a plastic replica to produce a projected image of the surface being inspected. Images of surfaces being compared are seen magnified, side-by-side in a viewing machine. The Faxfilm Surface Comparator is discussed in "The Science of Precision Measurement" (appendix A).

b. The Process is simple to use. A clear plastic film is moistened with a solvent which can be applied either to the film or to the surface being examined. The film is pressed against the surface for 30-40 seconds and then peeled off to form a reverse replica of the original surface. When placed in a microprojector the images of the surfaces can be compared. Comparison projection of the specimen with a known standard makes a roughness estimate possible.

5. Brush Surface Analyzer.

a. The brush surface analyzer is illustrated and its operation discussed in "Precision Measurement in the Metalworking Industry" (appendix A). It employs a stylus which explores the surface and amplifies the impulses from the stylus electrically, so that they can be indicated on a meter or recorded on permanent charts. The surface under test is traced with a fine stylus and its motions automatically recorded, in such a manner, so that the chart contains a record of:

(1) The number of irregularities traversed by the stylus.

(2) The depth of each irregularity.

(3) Regularities above and below the nominal surface.

b. The brush surface analyzer consists of the following:

(1) Shock-mounted surface plate - to provide a working surface.

(2) Drive head - to drive and support the stylus.

(3) Pickup arm - supports a diamond stylus, a piezoelectric crystal element, and a lever system which also allows vertical stylus movement over the irregularities.

(4) Calibrating amplifier - magnifies the stylus signals and delivers them to the recorder.

(5) Oscillograph - provides the graphic record of the amplifier output.

c. The average roughness can also be read directly using an RMS meter.

6. Profilometer.

a. The profilometer is illustrated in "Precision Measurement in the Metalworking Industry" (appendix A). It measures the height of surface roughness in much the same way as the brush surface analyzer. The RMS average roughness can be read on a meter at any instant in microns or the output can be recorded on paper.

b. The principle difference between the profilometer and the surface analyzer is that the stylus motion is transformed into electrical signals magnetically rather than by a crystal cartridge. The same principle is true of phonograph pickups where magnetic and crystal cartridges are used. The phonograph record groove is the surface being analyzed.

7. Bullet-Pull Force.

a. The force required to remove a projectile from its cartridge case affects the interior ballistics of a weapon. The crimping of the case to the projectile should allow a uniform bullet pull force in order to maintain a uniform velocity from round to round. This becomes increasingly important due to the factor of weapon tube wear. Acceptance specifications for complete rounds require that the bullet-pull force be verified as falling within specified limits.

b. Bullet-pull force is measured in a mechanical testing machine. The procedures are routine in that the round is inserted in the machine so that clamps grip the cartridge case while the projectile is held firmly in the crosshead, gripped, usually, between the bourrelet and rotating band. Motion of the crosshead at specified strain rates produces hydraulic pressure in the loading cylinder of the machine. The load indication is read directly from the testing machine dial, as a function of the hydraulic pressure.

APPENDIX E
CHARACTERISTICS OF PROJECTILES

1. Introduction. A projectile is a missile designed to be fired from a gun. Its development is intimately connected with the development of the weapon. Modern projectiles are of the general shape as illustrated at figure E-1. The body is cylindrical in form with a fairly long ogival head, a boattail base, a cavity of adequate capacity and, when required, a special armor-piercing cap and windshield. It can be designed for a nose fuze or base fuze. A detailed discussion of projectile characteristics is found in "Elements of Armament Engineering" and "Elements of Ordnance" (appendix E). A modern projectile should fulfill the following basic requirements:

a. Ballistics efficiency to insure:

(1) Maximum range.

(2) Stability in flight.

(3) Minimum dispersion.

b. Tactical effectiveness including:

(1) Effective fragmentation.

(2) Maximum explosive effect.

(3) Armor-piercing capacity.

(4) Specific effects required for special types.

c. Safety in firing including no prematures due to:

(1) Pressure or shock of discharge in weapon.

(2) Hot gases entering projectile base.

d. Facility in manufacture including:

(1) Forging and machining.

(2) Loading.

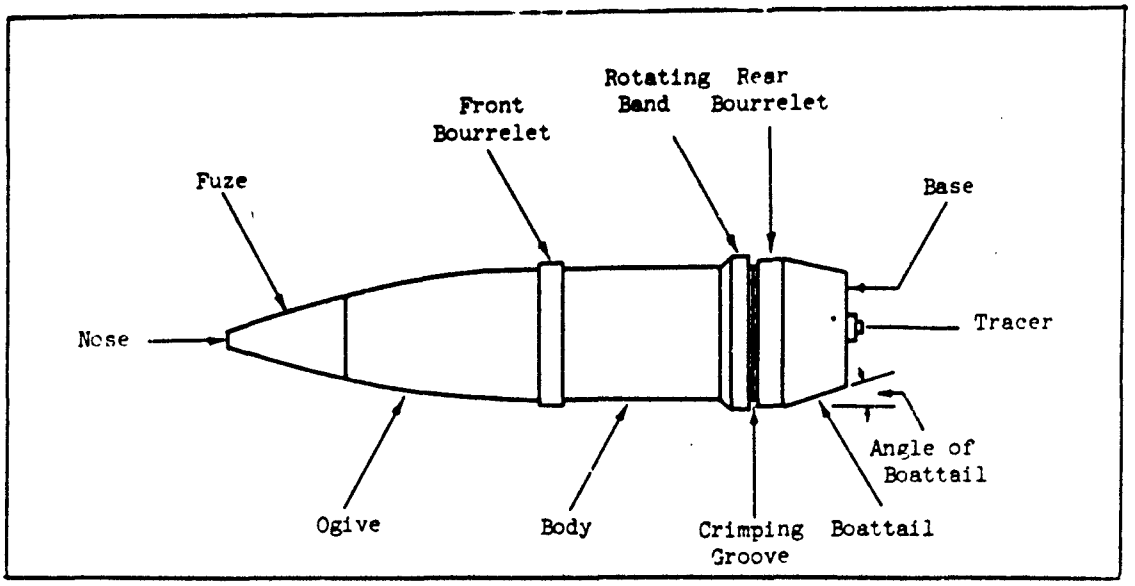

Figure E-1. Principal Parts of a Projectile

2. General. The principal parts of a projectile are illustrated at figure E-1. A definition of some of the more obscure terms is given below.

a. Body. The term body while applicable to the entire projectile, is specifically applied to the cylindrical portion between the bourrelet and the rotating band. It has a diameter smaller or less than those sections so that it does not contact the weapon tube wall. The length of the body is designed to secure increased weight, capacity, and improved ballistic performance.

b. Ogive or head. The ogive is that portion of a projectile in front of the bourrelet. The curve of the ogive is usually the arc of a circle whose center is on a line perpendicular to the longitudinal axis and whose radius is usually expressed in calibers.

c. Bourrelet. The bourrelet of a projectile is the cylindrical surface approximately 1/6 caliber in width at the rear of the ogive. It is accurately machined or ground to give a specified clearance between it and the weapon tube wall (lands of the rifling). Extreme accuracy is essential since the functions of the bourrelet are to

center the forward part of the projectile in the bore and to provide a bearing or guide for its travel through the bore. Some projectiles have front and rear bourrelets as shown in figure E-1 with the rear bourrelet supporting the aft section of the projectile. Other projectiles have a bourrelet just forward and adjacent to the rotating band.

d. Rotating band. The projectile is equipped with a band of relatively soft metal, such as copper, securely seated in the body. As the projectile passes down the bore, the soft band is engraved by the lands of the rifling and the rotation necessary for flight stability is imparted to the projectile. The band is slightly larger than the bore of the gun and tapered at the forward end. Rotating bands perform the following additional functions:

(1) Locate the projectile initially in a fixed position, axially, in the gun, and hold it in place when the gun is elevated.

(2) Act as a gas check, preventing the movement of powder gases past the projectile.

(3) Center the rear of the projectile in the gun and support its travel through the bore (especially in the cases where only a single bourrelet is used).

e. Crimping groove. A groove around the projectile in the area between the rotating band and the boattail. The groove provides a means for securely fastening the projectile to the cartridge case and is common only to fixed ammunition.

f. Base and boattail. The base of the projectile is that part aft of the rotating band (or rear bourrelet). It is cylindrical for a short distance and then tapers for about 1/2 caliber in length to the base edge to form the boattail. The length and angle of the boattailing employed depends on the projectile and its velocity. Boattailing is generally effective in low velocity weapons and in that part of the trajectory of high-velocity weapons where the velocity is below the speed of sound. The base as referred to in this appendix is the rearmost section of the projectile body.

APPENDIX F
ADDITIONAL REFERENCES

1. MIL-STD-252(EL), Classification of Visual and Mechanical Defects for Equipment, Electronic, Wired, and Other Devices.

2. MIL-STD-454C, Standard General Requirements for Electronic Equipment.

3. MIL-STD-171B(MR), Finishing of Metal and Wood Surfaces.

4. MIL-STD-173 (ORD), Systems for Painting and Finishing Artillery Materiel.

5. MIL-STD-272 (SHIPS), Welding and Allied Processes.

6. MIL-STD-403B, Preparation for and Installation of Rivets and Screws, Rocket and Missile Structures.

7. MIL-STD-177A, Rubber Products, Terms for Visible Defects of.

8. MIL-STD-186C (MI), Protective Finishing for Army Missile Weapons Systems.

9. MIL-STD-849, Inspection Requirements, Definitions and Classification of Defects for Parachutes.

10. MIL-STD-190B, Identification Marking of Rubber Products.

11. MIL-STD-193F, Painting Procedures, Tactical Vehicles (Tracked and Wheeled).

12. MIL-STD-194A (Ord), Systems for Painting and Finishing Fire-Control Materiel.

13. MIL-STD-209C, Slinging Eyes and Attachments for Lifting and Tying Down Military Equipment.

14. MIL-STD-299, Visual Inspection Standards for Nailed Wood Boxes and Wirebound Wood Boxes Used in Small Arms Ammunition Packing.

15. MIL-STD-284A, Visual Inspection Guide for Rubber Footwear.

16. MIL-STD-289A, Visual Inspection Guide for Rubber Sheet Material.

17. MIL-STD-293, Visual Inspection Guide for Cellular Rubber Items.

18. MIL-STD-297, Visual Inspection Guide for Hard Rubber (Ebonite) Items.

19. MIL-STD-298, Visual Inspection Guide for Rubber Extruded Goods.

20. MIL-STD-407, Visual Inspection Guide for Rubber Molded Items.

21. MIL-STD-294A, Visual Inspection Guide for Rubber V Belts.

22. MIL-STD-406, Visual Inspection Standards for Terne Plate Cans and Steel Boxes Used in Small Arms Ammunition Packaging.

23. MIL-STD-408A, Brushes, Electrical Contact Rectangular, Standard Designs and Dimensions for.

24. MIL-STD-413B, Visual Inspection Guide for Rubber O - Rings.

25. MIL-STD-00418B (SHIPS), Mechanical Tests for Welded Joints.

26. MIL-STD-644A, Visual Inspection Standards and Inspection Procedures for Inspection of Packaging, Packing and Marking of Small Arms Ammunition.

27. MIL-STD-646A (AT), Electrical Circuit (Wire Marking) Identification for Tactical Military Vehicles.

28. MIL-STD-686A, Cable and Cord, Electrical; Identification Marking and Color Coding of.

29. MIL-STD-651, Visual Inspection Standards for 20MM Ammunition and Components.

30. MIL-STD-663A, Visual Inspection Guide for Footwear Upper Leather.

31. MIL-STD-681B, Identification Coding and Application of Hook Up and Lead Wire.

32. MIL-STD-792C (SHIPS), Identification Marking Requirements for Special Purpose Components.

33. MIL-STD-1224, Visual Inspection Guide for Pneumatic Tires (Nonaircraft).

34. MIL-STD-1285A, Marking of Electrical and Electronic Parts.

35. MIL-STD-1473(MI), Standard General Requirements for Color and Marking of Army Materiel.

36. MIL-STD-636, Visual Inspection Standards for Small Arms Ammunition Through Caliber .50.